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TABLE OF CONTENTS

VOLUME XXXIII

NUMBER 1—JANUARY

NUMBER 2—MARCH

NUMBER 3—MAY

NUMBER 4—JULY

NUMBER 5—SEPTEMBER

NUMBER 6—NOVEMBER

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ABUNDANCE AND CONSERVATION OF THE BOB-WHITE IN OHIO.*

S. CHARLES KENDEIGH.

INTRODUCTION.

Ever since the eastern bob-white or quail, *Colinus virginianus virginianus* (Linnaeus), was put on the protected "song-bird list" in Ohio in 1917, after annually closed hunting seasons since 1913, there has been considerable discussion and agitation among sportsmen to have it recognized again as a game bird. Frequent attempts to introduce legislation in the Ohio Assembly, for having an open hunting season again put on the species, have been frustrated up to the present. The question has caused so much feeling between factions that a permanent settlement to the satisfaction of both sides of the controversy is very desirable, if it prove practicable. It is hoped that the present paper will contribute towards that end.

ESTHETIC AND ECONOMIC IMPORTANCE.

The bob-white is a very attractive and beautiful bird with a loud cheery song, and has endeared itself to all lovers of nature and to country folk in general. Many urge the complete protection of the species in the State on this basis alone.

The intelligent farmer has good reason to wish that the species be maintained in its normal numbers. The studies of Judd (1903, 1905), Nice (1910), and others show beyond doubt that the bird has great value as a destroyer of weed seeds and insects. Some 60 different species of weed seeds and 116 species of insects are consumed as food. Among the insects occur such distinctly undesirable forms as chinch bug, potato beetle, and striped cucumber beetle. The species consumes some grain, but this seems to be largely waste grain that remains after the crop has been harvested.

*Contribution from the Baldwin Bird Research Laboratory (No. 25) and Western Reserve University, Cleveland, Ohio.

IMPORTANCE AS A GAME BIRD.

The bob-white undoubtedly makes a fine game species in areas where it is sufficiently abundant. The hunting of bob-white is a sport of high order, since it demands skill, training, and patience, and requires a hardiness and love of the out-of-doors that may well be encouraged.

BASIS FOR CONSERVATION.

The above discussion shows that the bob-white is of legitimate interest to the lovers of nature, to the farmer, and to the sportsman. Can conservation of this species be based upon measures that will permit the realization of all these interests? This realization is possible only if the greatest care be taken to consider the safety of the bird as a species and the maintenance of a large number of individuals all over the State. One of the first studies that needs to be made in this connection is the determination of the actual population of the bird and the factors that are responsible for increasing and decreasing its numbers.

CENSUS-TAKING.

Since 1901, there have been reported annually in *Bird-Lore* magazine the results of one-day censuses of all species of birds, taken between December 22 and 27 by observers located all over the country. Since 1908 the number of census reports from Ohio have been sufficient to make possible some estimation of the number of bob-white present during this time of the year. These records have been compiled for the years 1908 to 1931, inclusive, with the results shown in Table I.

In arriving at an estimation for the total population of bob-white in Ohio, various factors must be considered. The total number of reports for different localities is not so important as the number of parties making these reports. It is necessary, in order to judge the amount of territory that was covered in the census, to determine the average number of miles traveled by each party per hour in the field for each year separately. A difficulty arises as to the width of this strip of territory over which the census-taker could have made an accurate count of the bob-white present. With some hesitation, this was estimated to be about 75 feet. Using this figure and knowing the average mileage covered per hour, the square mileage of

territory covered could be figured. A correction of this figure must next be made for the number of people making up the party. The average number of people per party ranged from 1.2 in 1908 to 2.4 in 1931. It is assumed that two people in a party will be approximately twice as efficient in making a census of bob-white as will one. This may not be strictly true in some cases, but seems to be the only legitimate way,

TABLE I.

TOTAL POPULATIONS OF BOB-WHITE IN OHIO DURING LAST 24 YEARS, ESTIMATED FROM BIRD-LORE CHRISTMAS CENSUS REPORTS.

Year	Total Number of Parties Reporting	Total Populations, Uncorrected	Total Populations, Corrected from Figure 1
1908	15	1,343,000	1,700,000
1909	10	814,000	600,000
1910	16	1,800,000	1,350,000
1911	21	1,128,000	1,500,000
1912	24	521,000	900,000
1913	12	345,000	650,000
1914	16	1,710,000	950,000
1915	16	349,000	1,200,000
1916	12	2,395,000	1,500,000
1917	11	369,000	1,000,000
1918	8	592,000	1,000,000
1919	14	2,706,000	1,800,000
1920	16	1,350,000	2,600,000
1921	17	2,549,000	3,500,000
1922	23	5,496,000	4,000,000
1923	16	2,506,000	4,100,000
1924	19	5,740,000	4,100,000
1925	24	5,008,000	3,700,000
1926	26	2,369,000	3,100,000
1927	34	3,561,000	2,500,000
1928	27	997,000	2,000,000
1929	33	3,018,000	2,000,000
1930	44	3,553,000	2,550,000
1931	42	2,307,000	3,350,000

without careful field tests, in which a correction may be made for the size of the party. The square mileage of territory covered per party is multiplied, therefore, by the average number of people constituting the parties during that year. Knowing the total square mileage in the State, the percentage of this area covered by a party of census-takers during an hour can then be determined.

The next step in this computation consists in figuring for each year separately the average number of bob-white seen

per party per hour in the field. When this is known, and the percentage of the total area of the State that is covered is known, the total population of bob-white may be readily computed. These are the figures given in Table I.

In this method of computation the attempt is made to eliminate, as far as possible, errors dependent upon variations in the human equation. Census-takers undoubtedly select their routes in order to get the largest possible number of birds of all species. Such a route may be at times through habitats where bob-white are most abundant, as along fences, hedge-rows, forest edges, etc.; but at other times this route will traverse woods, village streets, and other localities ill-adapted for bob-white. As areas unfavorable for birds of all

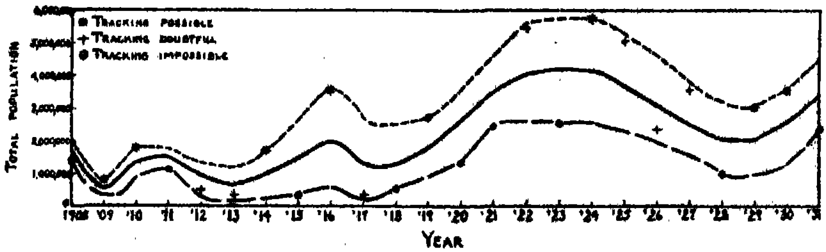

FIGURE 1. FLUCTUATIONS IN ABUNDANCE OF BOB-WHITE IN OHIO FROM 1908 TO 1931. The asterisk marks years with sufficient snow on ground to make tracking of birds possible; the cross marks years when the ground was only partially or lightly covered with snow so that tracking may or may not have been possible; and the circle marks years when the ground was bare so that tracking was impossible. Broken lines connect years when tracking was possible and years when tracking was impossible. The full continuous line represents the median and probably most accurate estimation of the total annual populations.*

species, including the bob-white, are generally avoided, estimates of total bob-white population based on these censuses will tend to be high. This is counteracted in part by the fact that census-takers do not use trained bird dogs, so that some bob-white in the most favorable places are undoubtedly missed. By giving each census-taker credit for covering a rather broad area of 75 feet on his trips, even when two or more persons take the census together, it is believed that the unfavorable "blank" spaces are accounted for.

Another possible source of error in these figures of total population lies in the effect which the weather on the day that the censuses were taken has on the number of bob-white

*An error in the population data for 1916, found when reading proof, is corrected in Table I.

recorded. A compilation was therefore made of temperature, cloudiness, wind, precipitation, and amount of snow on the ground on the days that the censuses were taken. None of these factors except the last appeared to affect the numbers of bob-white recorded. In a personal communication, Stoddard emphasized the importance which the amount of snow on the ground may have on the records obtained. When the ground is covered with snow, tracks of the bird may be readily found and easily followed so that it is logical to expect a larger number of birds to be recorded during those years than during years when the ground is bare. The importance of this factor is shown in Figure 1.

The actual figures of total bob-white population, as determined by the methods above described, were first plotted in Figure 1. Then the years were marked according to whether tracking was possible, doubtful, or impossible. The figure then showed clearly that many more birds were recorded during years with snow on the ground than during years when the ground was bare. A line was then drawn connecting the figures for those years with snow and another line connecting the figures for the years without snow. In general, the trends in fluctuation of population are very similar regardless of which curve is taken. Finally, a medium curve was drawn halfway between the other two. Probably this more nearly represents the actual total bird population in the State than does either of the two extremes. The corrected total population given in Table I are figures read from this medium curve in Figure 1 for the corresponding years. We would judge these figures to be accurate to within 25%, but whether or not they are this accurate must wait and be checked in the future by intensive field work over corresponding years. The *Bird-Lore* censuses are admittedly not all that might be desired to serve as a basis for an estimation of total population of birds, but furnish the only information available for the past two dozen years.

AVERAGE ABUNDANCE.

The average abundance of the bob-white in Ohio during the last 24 years is 2,152,000 birds, or one bird to approximately 12 acres. Since the species has been given continuous protection since 1913, the average abundance of the species may be figured from 1913 to 1931, inclusive. This is 2,400,000 birds, or one bird to 10.9 acres. The greatest abundance which is

recorded for the species during any year in this 24-year period is 4,100,000 in 1923 and again in 1924. This is one bird to 6.4 acres. The number of birds per acre would average higher if only agricultural land with favorable habitats were included instead of taking the whole area of the State. Undoubtedly also, the species varies in abundance locally in different parts of the State, being less abundant in some regions and more abundant in others.

Leopold (1931) found that one bird on two to four acres of farming land is the most frequent density of population in the north central states, with one bird on four to eight acres ranking a close second. One bird per acre is believed to be the "saturation" point of greatest possible abundance of bob-white. In "natural" areas of Florida, Stoddard (1931) found one bird on four to five acres. Likewise, on many preserves in southern Georgia, Stoddard found only one bird on four to five acres, while on others he found one bird on two acres, and on the best developed acres, one bird per acre.

FLUCTUATIONS IN ABUNDANCE.

In southern Georgia, Stoddard (1931) found that the bob-white population was essentially stable from year to year with no evidence of regular cyclic fluctuation in numbers. Variations of abundance occurred, but never exceeded 50%. The rather stable nature of the bob-white population in the south may be due, in part, to the absence of severe winter weather, particularly to the absence of snow.

Leopold (1931) has discussed in detail the abundance of bob-white in Minnesota, Wisconsin, Michigan, Iowa, Missouri, Illinois, Indiana, and Ohio. He likewise states that the quail population is very stable except along the very northern borders of the species' range. The recollections of local sportsmen, which Leopold compiled, show low numbers of birds in parts of Ohio in 1887, 1891, 1901, 1923, and 1928, and all over Ohio in 1918. The average interval between these seven known periods of scarcity is seven years in Ohio. In nearby states the period ran from four to seven years.

The curve of abundance of bob-white in Ohio based on the *Bird-Lore* census reports (Figure 1) shows low points in 1909, 1913, 1917–1918, and 1928–1929. The low point of 1909 is not well established, since it is based on records of only one year. This agrees with the findings of Leopold for low numbers

of birds in Ohio in 1918 and 1928, but does not agree with his report of low numbers in 1923, when this curve reaches its highest point.

Figure 1 shows that the bob-white reached peaks of abundance in 1911, 1916, and 1922–1924. The species was more abundant in 1922–1924 than in either of the other two peaks.

The time intervals between the low points in the curve of abundance are approximately 4, 4½, and 11 years, respectively. The time intervals between the peaks of abundance are approximately 5 and 7 years, respectively. This evidence is not sufficient to indicate that there are definite cycles in the abundance of the bob-white but does show that considerable fluctuations in abundance occur.

INBREEDING AND OUTBREEDING.

There is a widespread opinion among sportsmen that bob-white will decrease in size, vigor, and abundance through inbreeding, if the coveys are not scattered by shooting. In contradiction to this idea are the statements of some of the leading students of bob-white in America. Leopold (1931, page 54) states, "In short, there is not a shred of real evidence that quail inbreed if unshot, or that it would hurt them if they did." People apparently forget that the bob-white existed and thrived for ages before the advent of the white man and the shot-gun without ill effects resulting.

Stoddard (1931) has studied the question of inbreeding in bob-white. He states that hunting does increase, to some extent, the shifting of birds from one covey to another, but that the increased shifting due to this cause is not so much as might be expected, nor is the shifting and intermingling of birds from one covey to another dependent on hunting. There is some tendency for mating in the spring to take place between members of the same covey, but the covey is not a family group. The covey is made up of members of several different broods and of surplus cocks and unattached individuals. He found, through banding operations, that there is a shuffling of birds between coveys before mating begins regardless of whether or not there is hunting.

Dr. Baldwin, of our laboratory, is positive in stating that shooting does not break up coveys of bob-white as long as a sufficient nucleus of birds remains. Dr. Baldwin has spent

considerable time in the field in southern Georgia during the last thirty years, and was, in fact, responsible in large measure for organizing the Quail Investigation there under the able leadership of Mr. H. L. Stoddard. He makes this comment upon the subject of breaking up coveys and inbreeding:

"A number of the sportsmen, subscribers to the Quail Investigation, were either near friends of mine or members of my family, so that during each winter season I made many trips with them into the quail fields shooting with gun or camera. Most often I went with a nephew who had some fifteen thousand acres of quail fields and had been accustomed for many years to take about 1,000 quail each year from that area. His game keeper, Jim, was famous in that part of Georgia for his knowledge of the game and his ability to know each covey of birds in this entire area and, at will, to locate the covey and remember the exact number of birds in the covey. It was the daily experience to plan with Jim just what portion of the fields would be hunted for that day, and just what coveys would be gotten up. Jim would tell with extraordinary accuracy just how many birds were left in a certain covey when it was last shot out, and when the covey was flushed that number of birds would get up; or at times if birds were missing, it was judged and sometimes afterwards proven that poachers had been into the covey. So accurate were these observations as to number of birds, and so well could the numbers be traced throughout the winter that it was preposterous to say that coveys were broken up by shooting. Indeed this old tradition about breaking up coveys by shooting to prevent inbreeding was discussed and at times we would get up coveys on succeeding days on purpose to note that the numbers closely tallied with the number of birds left when last shot out. One who remains in the vicinity for a few hours after the covey is shot out will see the birds gather into a covey again, and usually no bird has been driven so far as into the territory of the next covey. The tradition that the health of the birds is improved by breaking up coveys in order to prevent inbreeding is subject to fatal criticisms."

East and Jones (1919) have discussed in detail the genetics of inbreeding and outbreeding among all sorts of animals and plants. They maintain that inbreeding in itself is not deteriorating to a race, but that it may weed out undesirable characteristics that ordinarily lie hidden in the genetic constitution of individuals. Such weeding out of the strains of weakness in a race may be desirable, as it leaves the remaining stock more uniform and healthy. This is the way that thoroughbred domestic stock has been originated and improved.

From these various studies, we may infer that if inbreeding were to occur in the bob-white population, there may be, at first a slight decrease in numbers due to the elimination of

individuals having unfavorable combinations of genetic characteristics, but that this would be followed by an increase and building up of a more healthy and vigorous stock. However, the striking fact is that there is no evidence that inbreeding occurs in the bob-white, nor that it is an important factor for consideration.

CAUSES OF FLUCTUATIONS IN ABUNDANCE.

Any one of several factors may be responsible in causing fluctuations in the number of birds. In the case of the bob-white, four factors have been singled out as of probable importance, namely, change in habitat (cover), occurrence of epidemic diseases, fluctuations in available food, and variations in climate. These factors may vary independently, but they produce a greater effect upon the bird when they combine and interact.

Leopold (1931) has stressed the great importance of cover to birds in the north-central states. Cover suitable for bob-white was much more abundant in the past than it is now, and he correlates this with a greater abundance of the species during the 19th century. Information is not available, however, to permit correlation between changes in cover and variations in abundance of the bird from one year to the next.

There is always the possibility that disease may be the active agent causing fluctuations in the abundance of a bird, although Stoddard (1931) found little evidence that disease was important with the bob-white in southern Georgia. Lack of food or the occurrence of severe weather may reduce the resistance of a bird to disease so that it may then become important.

During ordinary years there appears to be plenty of food available for the bob-white at all seasons, although late winter is a critical period. The bob-white selects its food from that which is most abundant, and, when it is able to find an adequate supply, is able to maintain its resistance and vitality (Errington, 1931, 1930).

The climatic factors which appear to be of particular importance are winter snowfall, summer rain, and temperature. Errington (1930, 1931) found that the bob-white is able to resist extremely low temperatures as long as food is available, but when snow covers the food supply, disaster results. Sleet storms and ice would have the same effect as snow in rendering

food unavailable. In our own studies with passeriform species (Baldwin and Kendeigh, 1932), we found that lack of food reduces a bird's resistance so that temperatures that are not exceptionally low become destructive. In discussing the mortality of bob-white, Leopold (1931) states that winter losses predominate in the northern tier of states and nesting losses in the southern. He believes that there is a direct killing of bob-white by climatic forces during severe winters, and that hard rains are destructive during the nesting season,

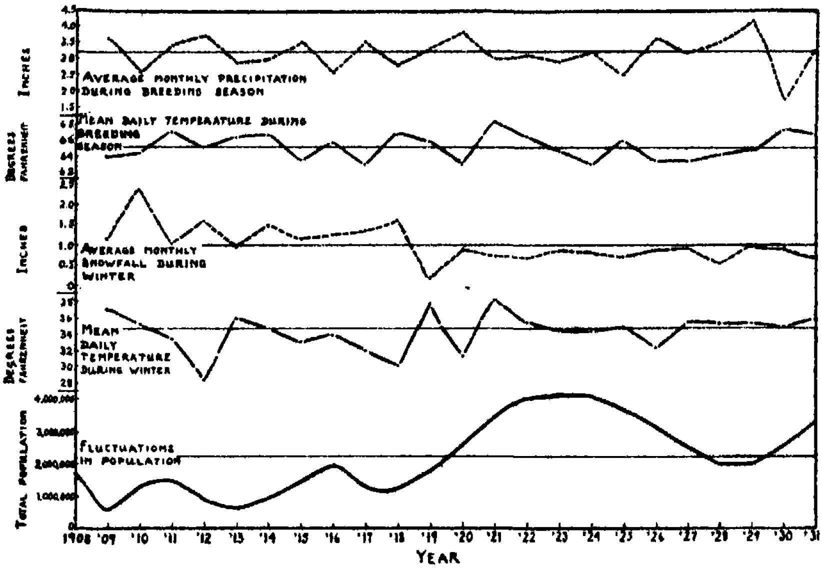

FIGURE 2. CORRELATION BETWEEN FLUCTUATIONS IN ABUNDANCE OF BOB-WHITE AND CLIMATIC FACTORS. The climatic factors considered here are average monthly precipitation and mean daily temperature during the breeding season (April, May, June, July, and August) and average monthly snowfall and mean daily temperature during the winter (November, December, January, February, and March). The narrow straight medium line running through each curve is the average value for the 23-year period (1909–1931).

particularly to young birds. Stoddard (1931) found that reproduction is usually higher and nesting mortality lower during dry seasons than during wet ones. Severe droughts are, however, unfavorable in Georgia because they reduce the percentage of eggs that hatch in nests that are placed on the hot parched ground.

With these points in mind, an attempt was made to correlate the fluctuations noted in the abundance of the bob-

white in Ohio with snowfall, summer precipitation, and mean temperature. The climatic data were compiled and averaged for the following localities from the Monthly Weather Review of the U. S. Weather Bureau: Cincinnati, Columbus, Dayton, Cleveland, Sandusky, and Toledo. In Figure 2, the average monthly snowfall and the mean daily temperature during the five winter months of November, December, January, February, and March, and the average monthly precipitation and mean daily temperature during April, May, June, July, and August are shown together with the curve of abundance of the bob-white. The effect of temporary periods of severe weather, lasting for a few days only, have not been analyzed in this paper.

The major point of significance in the curve of total annual populations (Figure 2) is the much greater abundance of the bob-white from 1919 to 1931 than from 1909 to 1918. An analysis of the curves for the four climatic factors indicates that this difference in the abundance of bob-white is most significantly correlated with a greater snowfall and a lower temperature during the winter for the earlier period. During the winter months from 1909 to 1918, inclusive, the snowfall averaged 1.41 inches per month compared with 0.76 inches per month from 1919 to 1931. The mean daily temperature during the winter was 33.6° F. for the earlier period and 35.0° F. for the latter. Since the species was given continuous protection from hunting beginning in 1913, this factor was not responsible for determining the lower numbers during the earlier period, although it may have been a contributing factor during the first four years.

The dip in the population curve during 1912–1913 is correlated with unusually severe conditions in 1912, when winter temperature was very low, snowfall high, and, in addition, heavy precipitation occurred during the breeding season. In 1913, climatic conditions ameliorated considerably, but this was not marked by an increase in number of birds. Apparently, other factors came into play this year which our data do not bring out.

The dip in the curve of bob-white abundance in 1917–1918 is correlated with falling winter temperature and increasing amount of snowfall becoming particularly severe during the latter year. Heavy precipitation and low temperature prevailed during the breeding season of 1917, but improved in 1918.

The last big depression in the abundance curve, beginning in 1925 or 1926 and culminating in 1929, is not correlated in these data with severe winter conditions but appears to be most significantly related with high precipitation during the summer season, this being combined with summer temperatures persistently lower than normal.

The rise in the curve of bob-white populations in 1910–1911 is not marked by particularly favorable climatic conditions. Snowfall was heavier in 1910 than in any other year, but this was apparently compensated for by the high average temperature which prevailed. The winter of 1911 had less snow, but the temperature averaged lower. It may well be that neither heavy snowfall nor low temperature during the winter is particularly effective in reducing the number of bob-white except when these conditions occur together. This they did during the following year of 1912, and then there appeared a decrease in birds.

There is little to mark the years of 1915 and 1916 when an increase in bob-white is noted. Climatic conditions were not particularly favorable nor markedly severe. The closing of the hunting season for bob-white during these years may well be responsible for the increase in numbers of birds noted.

The long upward trend in abundance of bob-white reaching the peak numbers in 1923 and 1924 was given a good impetus in 1919 by unusually favorable winter conditions and moderate breeding ones. During 1920, the climate was less favorable. The winter was cold, although the amount of snow was very moderate. During the summer, low temperatures were combined with heavy precipitation. It is quite possible that a minor fluctuation in abundance occurred this year, but does not show in our data. The following year, 1921, was again very favorable climatically, probably one of the best during the entire 24-year period. The following four years were moderate.

The long downward trend in abundance of bob-white beginning in 1925 was stopped abruptly and given an upward curve again in 1930. This latter year was marked by a moderate winter and a warm, very dry summer. The upward trend in numbers persisted in 1931, and there is every reason to suppose that it was again augmented in 1932.

Summarizing the correlations between climate and population trends in the bob-white that have been noted, it appears

that severe winters marked by low temperatures combined with heavy snows are generally disastrous to the species and will greatly reduce it in numbers. Unfavorable climate during the breeding season, i. e., heavy rains and low temperatures, acts less precipitously upon the numbers of birds, but will reduce the population by affecting the amount of reproduction.

It is worthwhile to note here that the positive correlation that has been made between climate and trends in population of bob-white not only brings out the importance that climate has in affecting the numbers of birds but also substantiates, to some extent at least, the general fluctuations noted in the population trends themselves.

MORTALITY.

Errington (1930, 1931), who has kept large numbers of coveys under observation throughout winter seasons, found a mortality of less than 7% during one winter that was mild and almost snowless. During another winter, he found a mortality of 30%, as a consequence of severe cold and heavy snow during January.

As the result of the severe winter of 1912 followed by a none too favorable breeding period, there was a decrease of 40% in the bob-white population of Ohio. In 1917 and 1918, cold, snowy winters were followed in 1917 by unfavorable climate during the breeding season but by favorable climate during the breeding season of 1918. This corresponds with a decrease in population of birds amounting to 33% over what it was in 1916. The winter of 1918 was more severe than in 1917, but this was apparently offset by a more favorable breeding period.

During what appears to have been moderate winters but unfavorable breeding periods from 1926 to 1929, inclusive, there was an average decrease in total population of 14% per year. This means that the reproduction of the species during these years enabled it to compensate very little if any for the normal rate of mortality of the old birds even during years when the old birds were not subjected to particularly severe winter conditions.

RECUPERATIVE POWERS.

The reproduction of bob-white must fully compensate for the annual rate of mortality of adult birds even during favorable years, if the population is to remain constant. If an

increase is to occur in the number of individuals, not only must this be done, but also a surplus of young must be raised. During the 12 years in this record when an increase in population was noted, this surplus has amounted, on the average, to 39% of the previous year's numbers. If the figure of 14%, given above, be assumed as representing somewhere near the normal rate of dying off of adult birds under favorable climatic conditions, then the total recuperative powers of the bob-white under favorable breeding conditions would be approximately 53%. In other words, a pair of adult bob-white is able to raise about one bird to maturity, on the average, during favorable years. This figure needs to be checked by more intensive field study, but furnishes a preliminary figure with which to work. An unfavorable year, therefore, that causes a loss of birds amounting to 33–40% of the previous number will not be fully compensated for until the second favorable season for reproduction.

METHODS FOR INCREASING ABUNDANCE.

The bob-white is not so abundant as is desirable if the greatest possible benefit is to be derived from its presence in the State. After severe winters or unfavorable breeding seasons the species may be very scarce. How may the number of bob-white in the State be increased?

The devastating action of severe winter weather may be mitigated locally by providing food artificially. Errington (1930, 1931) recommends the leaving of isolated shocks of corn near favorable habitats of bob-white. The artificial feeding of the entire population throughout the State during unfavorable years seems impractical, without the ardent and enthusiastic co-operation of the entire farming population. This will require considerable in the way of an educational policy. The farmer holds the control in all measures that are designed to permanently increase the number of bob-white, and unless his co-operation is solicited, all these measures of conservation will fail.

Leopold (1931) is working on a method of game management in states where hunting is permitted. He suggests that the farmer consider the natural breeding and protection of bob-white on his farm as a crop to be actively encouraged, and that remuneration be sought from levies on sportsmen who desire to hunt on his property.

For increasing the population of bob-white, the maintenance

of a proper habitat for shelter and food is an absolute prerequisite. Unless food is available in abundance at all seasons of the year with the proper shelter from enemies, any artificial means of multiplying the number of bob-white is futile. If the proper habitat is available or can be increased in extent, the bob-white will ordinarily increase in abundance on its own natural resources until the saturation point is reached.

The natural habitat of the bob-white consists of open woods, with plenty of shrubs and grass, shrubby and grassy fields, fallow fields, shrubby fence rows, and thickets adjacent to open land. Such habitats could be readily encouraged by farmers if the desirability of doing so were effectively brought to their attention. The bob-white must have suitable cover to furnish it with shelter from enemies, shelter from climatic elements, and as a location for placing and hiding the nest. The bird seldom wanders far from shelter of some sort. The flight of the bird is swift and powerful for short distances but cannot be maintained for long, so that shelter must be available within easy reach or the bird will be exposed to the attack of many predators. This cover can be created by the farmer with little or no loss to normal operations. Osage-orange hedge-rows are very favorable, or, if these are not practical, the allowing of wild shrubbery and briars to develop along fence rows, fence corners, farm lanes, or other out-of-the-way places will well serve the purpose. If semi-open woodlots, river bottoms, hilly areas, or other areas unsuitable for crops are available, the bob-white will flourish if the natural growth of thickets is not prevented and grazing by domestic stock is not intense. Stoddard (1931) and Leopold (1931) discuss many practicable features in adapting farm country to bob-white.

Attempts have been made from time to time to introduce into northern states a bob-white (*Colinus virginianus texanus*) from Texas and Mexico to augment the native stock. According to Leopold (1931), 6,000 such birds were liberated in Ohio in 1916, but it is doubtful if many of these survived. Introduction of these foreign birds is not to be recommended because the southern bob-white is of less vigorous stock, weighs less, and is less resistant to northern winters. By interbreeding with the native northern bob-white, it may readily undermine the vitality and natural hardiness of the entire population.

The practicality of raising bob-white artificially for liberation is a question. This has been successful in the case of a few

other species. At present, the cost of hatching bob-white in incubators or under hens and raising the chicks to maturity is too prohibitive for extensive liberation purposes. However, methods are now under investigation, and it is not unlikely that in the near future, the total expense of raising a pair of adult birds will be materially reduced. There is no reason to believe that artificially reared birds will be any more resistant to cold, heat, snow, lack of food, rain, and droughts than is the native stock. Therefore, there is the chance that a large proportion of any such release of artificially reared birds might be destroyed within a few months.

Even if the artificial rearing and liberation of bob-white may some day become practicable, this undoubtedly could not be done extensively enough to furnish birds directly for hunting. Such birds will best serve the purpose of adding to the breeding stock, as the maximum increase in population would have to be brought about by natural production. However, there is no value in liberating birds except into areas having suitable habitats to receive them. Without abundant food and shelter, they would not long survive.

The whole problem of increasing the population of bob-white reduces down to the establishment and expansion of habitat areas containing suitable cover and food. The preceding study of the fluctuations in the population of bob-white during the last 24 years indicates that, where given proper protection and habitat and when the climate is favorable, the species is capable of rather rapidly increasing its numbers by natural reproduction. With the increase in abundance, the birds must of necessity expand their areas and spread into new and favorable regions. It seems, therefore, that if new habitats for the bird are formed, natural reproduction will soon enable the species to fill in these areas without the necessity of liberating either imported birds or those that have been reared artificially. If, however, local areas of considerable size are found in the State in which no breeding stock is present, the liberation there of artificially reared native stock to serve as a nucleus for breeding purposes may be desirable; or birds in *nearby* localities may be trapped and imported.

RECOMMENDATIONS AS TO CONSERVATION.

In southern Georgia, Stoddard (1931, page 341) states that on some places it is safe to shoot approximately 25% of the

population of bob-white annually, where control of natural enemies is fairly adequate. On very large tracts of preserved land, as where several estates are located in a group and the owners are co-operating in the control of the enemies of the bob-white, it may be possible ultimately to harvest up to 50% of the crop and still leave a sufficient breeding nucleus. On other areas, no surplus is produced for hunting. Leopold (1931, page 87) states that an annual kill of 50% of the population is, at present, unsafe in the northern states, and indicates that 33% is about the maximum from which the species can recover during favorable years.

It is absolutely essential if the population of bob-white is not to be depleted that no more birds die each year than are raised, whether their death be due to natural causes or to hunting. Our population data for bob-white in Ohio, indicate, as was discussed above, that during favorable years, an average increase of 39% of the previous year's population occurs. This represents the maximum number available for hunting purposes during the 12 years in which a surplus of birds was produced. During the other 12 years in this period, the number of birds remained the same or there was a decrease in abundance. During these years, no birds at all would have been available for hunting.

If, 2,400,000 birds be taken as the average bob-white population for the State and 39% of these are available to the hunter during favorable years, this amounts to approximately 936,000 that may be killed. According to information kindly obtained for us by the Ohio Division of Conservation, there have been over 400,000 hunting licenses given out during each of the last four years. All of these licenses stand for potential hunters of bob-white. The total number of birds available for these 400,000 hunters would average about 2¼ birds apiece for the season. This number is so small as to make the hunting of this species an impractical one for sport, even if such a small bag limit could be enforced.

The gravest danger lies, however, in possible extermination of the species in the State during those years when no increase or surplus is produced due to unfavorable breeding conditions, or when the number of breeding pairs have been reduced due to severe winter conditions. The killing by hunters of 936,000 birds during a single year would have wiped the species entirely out of existence in Ohio in 1909, 1912, and 1913 and nearly so

in 1914. A similar kill in 1917 or 1918 would have so reduced the number of birds left for breeding that recovery would have been insufficient to permit the species to survive the hunting season of the following year. Similarly, if hunters had killed 936,000 birds per year during the period beginning in 1926 when the bob-white population was decreasing from natural causes at the rate of 14% per year, the species would have been exterminated in the State by 1928. It is against this danger that the people in Ohio must guard, since it has been demonstrated above that the species is of interest not only to the hunter but also to the farmer and to the bird lover, and their interests must be considered.

The conclusion must be, therefore, that the population of bob-white in Ohio is *not* of sufficient size to permit a *general* open hunting season throughout the State. If hunting is to be permitted at all, it must be confined to local areas where the bird is sufficiently abundant to withstand the drain upon its numbers, where the amount of hunting may be carefully controlled, and where protection and food may be furnished during periods of stress.

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THE STATE PARKS OF HOCKING COUNTY, OHIO.

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Not far from Athens and to the southwest of Logan, the county seat of Hocking County, is an area of country unequalled in Ohio for its scenic beauty. This region has a wealth of natural beauty, for the most part still in its original condition. The attractiveness of this rugged area is enhanced by the virgin stands of hemlocks, poplars and oaks and the profusion of ferns, shrubs and flowers. Through the steep-sided, shady gorges wind trails through virgin forest made up of giant trees, the like of which are seen in few places in Ohio. This region is especially interesting to geologists and botanists as well as to those who love nature and the out-of-doors.

The recreational possibilities of the state parks are being appreciated to a greater degree each year, as indicated by the increasing attendance. The total number of visitors, coming from 38 states and Canada, in five recreational areas in Ohio, during the first ten months of 1931, was 256,557. Of this number 186,557 visited the parks in Hocking County apportioned as follows: 51,648 at Ash Cave Forest Park, 53,049 at Rock House Forest Park, 75,765 at Old Man's Cave Forest Park and 6,095 at Cedar Falls Forest Park. The attendance figures compare favorably with those of the larger better known national parks of the country.

The state park domain includes Ash Cave Park of 262 acres, Old Man's Cave Park of 1,010 acres, Cedar Fall's Park of 30 acres, Conkle's Hollow Park of 723 acres, Rock House Park of 517 acres and Little Rocky Park of 290 acres, a total of 2,832 acres in the Hocking County series of State Forest Parks.

Under the able leadership of State Forester Edmund Secrest, who has so faithfully served Ohio for the past 26 years, a program was inaugurated and maintained, whereby tracts of forest land were set aside in accordance with a definite policy of conservation. Through Mr. Secrest's efforts, the State Forest Law was passed (1915) and more recently an amendment to it, which enables the state to acquire by purchase or gift

such areas which it is necessary to receive for the public good and may include sites of scenic value, virgin woodlands, and areas desirable for recreation and reforestation. Through the operation of this law, Ohio has acquired a total acreage of more than 50,000 acres; 45,429 acres of State Forest and 4,769 acres of State Forest Parks. Perpetuation of our timber supplies, protection from soil erosion, preservation of natural beauty are the fundamental principles of the forestry program in Ohio.

The aim of the park authorities is to maintain the natural features of the region in all their pristine beauty. Here we have an area which is for the most part a wilderness. One can find roads cut through country that has remained almost unchanged during the last fifty years. Another excellent feature about these parks is their accessibility. They are easily reached by improved roads. Fire hazards have been removed, water supplies provided, camp sites and parking places cleared, paths cut through the forests, and steps cut in the solid rock at points where travel is difficult, all of which add to the wilderness spot that touch of civilization so desirable to tourists, but which park authorities are anxious to avoid as much as possible. Artificial conditions which are necessary, are restricted to limited areas on the outside, so that the natural beauty for which the place was secured, might remain unchanged as far as possible.

The saddest of sights are the abundant evidences of vandalism in the parks throughout the country. I refer to the writing of initials and names and other inscriptions on the rocks, the destruction of signs, the plucking of wild flowers and tearing up of shrubs and young trees and the indiscriminate disposal of refuse. Either we are not a law-abiding country or our education has failed to give us a sense of responsibility for the protection of the beauties of nature. Students in our schools should be taught not only love for nature but its protection as well. Community organizations can render a good service in promoting a sentiment for the suppression of the various forms of vandalism in Ohio woods.

PHYSIOGRAPHY AND GEOLOGY OF THE AREA.

The region is a portion of a maturely dissected upland, commonly known as the Appalachian Plateau. The highlands consist of long, narrow ridges which are deeply indented by hollows and gullies, where small streams have worked their

way up the slopes, forming many minor projections on the ridges which present a very rugged or serrated appearance. The highland plains have been so completely dissected by major streams and their tributaries, that the remnants appear as a network of long ridges with narrow summits and steep slopes. Farming is largely confined to the summits of the ridges and along the valley plains. The hillsides are forested or are used for pasturage. The higher ridge-crests stand at an elevation ranging from about 1,040 to 1,160 feet above sea level. The majority of the hills are below 1,100 feet and the valleys have an altitude ranging from about 680 to 780 feet above tide, the relief being approximately 200 to 375 feet. Generally speaking the bottoms of the deep, narrow gorges are perhaps 200 feet from the top of the cliffs which form their walls. The area is drained by Pine Creek and Queer Creek and their tributaries. These streams unite to form Salt Creek, which flows southward into the Scioto River. They occupy broad, mature valleys and some of the tributaries have narrow flood-plains in their lower courses.

A few miles to the southwest of Logan, breaking off sharply from the rounded hills and broad, fertile valleys on the uplands which surround the city, the country becomes rugged, with well-defined, deep, rocky gorges and narrow valleys. There are two districts in which the gorges appear, a south one along the three branches of Queer Creek and a north one on Pine Creek. In the Queer Creek district there are eight or nine miles of gorges, including Ash Cave on the lower or East Fork, Cedar Falls on the central branch and Old Man's Cave on the upper end of the north gorge, known as "The Gulf." The Pine Creek district contains four gorges and narrow valleys and six or seven smaller ones about a mile long, all running south into Pine Creek Valley. All the streams which flow into Pine Creek from the north occupy deep, narrow chasms varying from 50 to 175 feet in depth. They are heavily wooded with hemlocks and hardwoods. These gorge-like valleys are less frequented than the others and to those who enjoy tramping, away from the well-trodden paths, this region is especially delightful. Naming them from the east these parallel valleys are as follows: Big Rocky, Little Rocky, Springer Hollow, Crane Hollow, Conkle's Hollow, and Spruce Run, all of which, with the exception of Big Rocky and Crane Hollow, are state parks. North of the Pine Creek valley is Rock House Park. It is

located at the upper end of a small tributary to Laurel Run, which flows into Salt Creek.

If one stands on the high points on the ridge-crests or on the fire-lookout near the Rock House, he is impressed with the remarkably even sky-line. In Hocking County and adjacent areas, the main ridges along the water divides rise to a rather uniform height, the average of which is not far from 1,060 feet above tide. The variation is commonly between 1,020 and 1,100 feet. This level marks a peneplaned surface which has been uplifted and dissected by subsequent erosion to a fragmental condition. It rises gradually eastward and can be traced into, and is correlated with the Harrisburg peneplane of western Pennsylvania. As the result of the development of this surface, an earlier peneplane, commonly known as the Cretaceous but now believed to be younger, was almost completely removed. This surface, well-developed on the ridge-crests of eastern Pennsylvania, has been referred to as the Schooley (Kittatinny) peneplane. The Harrisburg surface was uplifted and dissected, the streams cutting deep valleys with wide gradation plains along their courses, reducing the divides between the drainage basins to lower levels. This peneplane, if it may be so called, is known as the Worthington in Pennsylvania, where it appears as a broad strath along the major streams. It is far less complete than the Harrisburg surface and extensive remnants of the latter appear over wide areas. In Hocking County, in the park area, the Worthington surface stands at an elevation averaging about 920 to 940 feet on the spurs along the larger streams, but in general is nearer 1,000 feet for the entire area; the average altitude of this surface for Ohio is not far from 1,000 to 1,100 feet. It slopes gently upward into the Harrisburg level and is somewhat higher near the main divides and lower toward the central portions of the drainage basins. During Worthington time the streams dissected the Harrisburg surface and cut broad valleys well toward their headwaters. The Harrisburg and Worthington peneplanes occupy about one-third of the total area.

In late Tertiary time, just before the ice age, a still lower erosion surface, the Parker Strath, was developed by erosive agencies. The term "Parker Strath" is applied collectively by Wilber Stout, of the Ohio Geological Survey, to the remnants of old valleys which stand well below the Worthington level.

This new cycle of erosion was inaugurated by a slow uplift of the land as a result of which the streams were rejuvenated and began carving valleys in the elevated surface. The streams maturely dissected the older surfaces and cut rather broad valleys with moderate slopes, 200 to 290 feet below the mean level of the Worthington peneplane. The further development of the Parker cycle was arrested by the advance of the glaciers of Pleistocene time, which caused a general modification of the drainage systems of the region. Since the ice age, the streams have been engaged in eroding to still lower levels. Remnants of the Parker Strath appear along Pine Creek and Queer Creek at an elevation of about 700 feet. The valley slopes rise rather abruptly from the Parker level to the Worthington surface, then much more gradually to the Harrisburg peneplane, remnants of which occur on the higher ridges.

There is abundant evidence that the youthful streams which occupy the gorges are at present actively cutting headward, dissecting the upland valleys, which are broad and shallow. The latter border the gorges and break off abruptly at the heads of the valleys which terminate in a precipice that usually overhangs. On the upland is displayed the ancient topography of the Harrisburg and Worthington cycles, and below, the more rugged topography produced by subsequent erosion. It is true that the weaker rocks above the Black Hand conglomerate have allowed greater erosion and hence broader valleys would result, and the sharp change from the upland to the gorges below could be in part the result of a difference in the resistance of the rocks to the erosive agencies. The same principle is the explanation of the rock terraces in valleys such as the Grand Canyon of the Colorado River.

The formations exposed in Hocking County were laid down during the Mississippian and Pennsylvanian periods. The principal formations belong to the Waverly group, the lower division of the Mississippian. The sandstones, conglomerates and shales of the Waverly have a total thickness of nearly 1,000 feet and can be grouped in several distinct members. The subdivisions of the Waverly in Hocking County, according to J. E. Hyde* are as follows, the Bedford shale, Berea grit, Sunbury shale, Cuyahoga and Logan formations. The only formations which concern us here are the Cuyahoga and Logan. Each of these have their subdivisions. The Cuyahoga, about

*Stout, Wilber, Geological Survey of Ohio, Bull. 31, p. 43, 1927.

600 feet thick, is composed of three members, the Lithopolis, Fairfield and Black Hand. The Lithopolis is made up of shales with fine-grained sandstones, the Fairfield of coarse sandstones and conglomerate, and the Black Hand of massive, cross-bedded sandstone and conglomerate. The Logan formation is subdivided into four members, the Berne, an evenly bedded conglomerate; the Byer, a fine-grained sandstone; the Allensville, a coarse sandstone, and the Vinton, a fine-grained sandstone and shale. On the ridges, above the Waverly group, lie the lower divisions of the Pennsylvanian Coal Measures, consisting of shales, clays, sandstones, conglomerates, coal and thin beds of fossiliferous limestone. The formation which concerns us most in a description of the features of the parks, is the Black Hand member of the Cuyahoga formation. This member is thick in Hocking County, being from 100 to 200 feet. It is for the most part a massive, conglomeratic sandstone, forming numerous prominent ledges in the streams which cut deeply into it. Where the streams have cut into it to any great depth, steep-sided gorges are produced. The walls or cliffs of these narrow valleys are usually in a vertical or overhanging position. The scenery of the park area is almost wholly the result of the weathering and erosion of the hard, resistant Black Hand member. A more detailed description of this member would include the fact that in Hocking County it is non-fossiliferous and is made up of sandstone and conglomerate. It is commonly sandstone with small pebbles of white quartz varying in size from a pea to one-fourth or one-half of an inch in diameter, scattered through the body of the sandstone in thin streaks. It is beautifully cross-bedded in places. The color varies, being dark brown or red on the outside where it is weathered. Where covered with lichens or moss it presents a green appearance. Beneath the weathered portion the sandstone is yellow or buff and in some places red or orange-red. Differential weathering has added to the picturesqueness of the cliffs. The beds of sandstone and conglomerate of the Black Hand member vary greatly in their resistance to weathering and erosive agencies. The weaker beds frequently form hollows or caves, whereas the more resistant layers stand out as projecting ledges or form benches. The Black Hand member is broken into huge blocks by joints; the wide spacing of the joints and the thickness of the beds is responsible for its massive character.

At present the dip of the beds is about 30 to 35 feet per mile to the southeast. At the time the Cuyahoga formation was laid down, Ohio was a shallow sea. A study of the Black Hand conglomerate and sandstone appears to indicate that strong currents were sweeping gravel from the southeast. The coarseness of the material, the abundance of cross-bedding and its direction of slope to the north, indicate delta growth or bar development under strong oceanic currents. When traced into Pike County to the westward and southward into Scioto County, the Cuyahoga conglomerates change rapidly to shale. Where the Black Hand member is thick and composed of sandstone and conglomerate the picturesque gorges are present, but where it is shale these features are absent.

FLORA.

A description of the park area would not be complete without a brief discussion of the flora of the region. According to State Forester Edmund Secrest, the Hocking County Park area has the finest stand of virgin forest in Ohio. It is least disturbed of any forest in the state; in some of the gorges few if any trees have been removed. In Cedar Falls valley stands what is said to be the tallest tree in Ohio, a hemlock 149 feet high and 40 inches in diameter. The value of the timber, in the Rock House Forest Park, at the time of purchase was worth more than the purchase price of the area. The forests of the region are interesting because they represent different types, the one in the gorges and narrow valleys the cool, northern forest as is found in New England and northern states and another on the uplands which is a southern type. The northern forest is represented by the hemlock, beech, sugar maple, and yellow birch and the southern by the chestnut, tulip-tree, pitch pine, jersey pine and sorrel-tree.

The Hocking County area has long been known by Botanists as one of the richest collecting grounds in Ohio. According to the report by Griggs,* in its general relationships the flora may be described as an outlier of the great Allegheny Mountain flora, from which it derives a considerable number of plants, like the Great Rhododendron, which do not occur elsewhere in Ohio. There are also a number of plants, like the Lycopodiums, which belong in the Canadian area and come down into Ohio

*Griggs, Robert F., A Botanical Survey of the Sugar Grove Region. Ohio Biological Survey, Vol. I, Bull. I-IV, 1913-1915, pp. 248-340.

from the north, reaching their southern limits in this region. There is a third element of southern plants, such as Aralia Spinosa, which stretch up from Kentucky and Tennessee and reach their northernmost limits in this area. The region is therefore interesting because of the possibilities of collecting, the study of the geographic range of plants and the ecology.

The deepest forest in the region is that formed by the hemlock, which is most luxuriant on the sides and bottoms of the deeper ravines. In the deeper gorges, conditions more nearly resemble those of the tropical rain-forest than anywhere else in the area. The humidity is high and the shade is so intense in some places as to prohibit the growth of plants other than the forest trees themselves. The Liriodendron forest occurs under conditions little different from the hemlock forest it is replacing. Its most typical development is present in the short, steep ravines, surrounded by high hills, within which the timber is unusually tall, straight and free from knots and wind checks. The tulip-tree is most characteristic of this type of forest. Chestnut, hemlock, butternut, American beech, red maple, tupelo, shagbark hickory, white oak, quercitron oak, sweet birch and red mulberry occur in order of abundance. In general a variety of smaller trees and shrubs grow beneath the forest canopy. Among these are the witch-hazel, flowering dogwood, wild hydrangea and others. The herbage is composed of a large number of species. In the most shaded woods, herbs with evergreen or hibernating leaves are abundant and conspicuous. Where not too shaded there is a rich development of vernal herbs with showy flowers. Later in the summer the places of these are taken by another group. The phanogams without chlorophyll are represented by the parasitic squaw-root and beech-drops and saprophytic Indian-pipe and smooth pine-sap.

The upland forest is divided into the pine and oak forests. The former occupies the poorest soil capable of supporting arborescent plants and bears a general resemblance to the pine barrens below the glacial moraines. The most important trees are the pitch-pine, scrub-pine, quercitron oak, chestnut and sorrel-tree. The pine forest occurs on the more exposed ridges where conditions are severe. Where the conditions are less severe the pines give way to the hardwoods and a mixed oak forest. The rock chestnut oak is sometimes the dominant tree. With it are present the white oak, quercitron oak, sorrel-tree,

chestnut, shagbark hickory, tupelo, and red maple. The upland oak forest coincides with the limits of arable soil and originally covered a large part of the region. As a result of lumbering most of the oak today is the worthless black oak.

PROCESSES INVOLVED IN THE FORMATION OF THE GORGES AND THEIR FEATURES.

The canyon-like valleys are youthful and exhibit all the characteristics of youth, such as waterfalls, clear, swiftly-flowing streams actively cutting downward, steep walls with bold rock outcrops and a V-shape or box-canyon cross-section. The rate of down-cutting has been rapid and weathering and erosion have not been sufficient to reduce the resistant Black Hand conglomerate to slopes, resulting in narrow, steep-sided valleys. Most of the streams in the region terminate in "coves" or steep-walled, amphitheatre-like slopes. The head of the valley usually ends abruptly in a semi-circular, overhanging cliff, or a series of ledges forming waterfalls or rapids. Above the cliff, the streams flow in broader, shallower valleys, which represent an older erosion surface. There is much evidence that the streams are at present actively extending their gorges headward. Usually the "coves" are present at the heads of the gorges, but in at least one case, at lower Old Man's Cave, there is one which does not occur in that location. The streams in cutting downward have in many instances produced a series of rock benches, forming one might say, giant steps up the valleys.

In the "coves" at the heads of the gorges, as at Cedar Falls, Ash Cave and Conkle's Hollow, not to mention others, there are usually fine examples of pothole action. The undermining of the base of the cliff by pothole action is doubtless the cause, in large part, of the gradual retreat of the falls and the lengthening of the gorges. The sandstone caves, so common in the region are the result of weathering and pothole action in the "coves," and undercutting by the streams where they impinge against the walls of the narrow gorge. The streams are, with few exceptions, temporary ones. During a dry summer, water flows through the valleys only during periods of heavy rainfall. At such times the streams have great volume and consequently great erosive power.

There is evidence to indicate that the jointing of the conglomerate is to some degree responsible for the canyon-like

valleys. The Black Hand member is broken into huge blocks by at least two joint systems, running at about right angles to each other. The tendency is for the smaller streams to follow the larger joints which offer less resistance to erosion. At Ash Cave, Cedar Falls, Conkle's Hollow and other places, especially where there are small tributaries, one can observe the tendency to follow the lines of least resistance along the joints. The block-jointing tends to produce angularities of the gorge walls and is also responsible, to some degree, for their vertical position.

Differential weathering is also the cause of some of the picturesque features of the gorges. Water, carbon dioxide, and oxygen find their way into the joints and bedding planes in the conglomerate and enlarge them, making it easier for running water to erode. Where the rock is resistant to solution or chemical decay, the beds project and where rapid weathering takes place, caves with overhanging ledges are produced. Rock decay along the joints has allowed trees and shrubs to take hold and by extending and enlarging their roots, the rock is further disrupted. In the environment of the shady glens the moisture content of the air is near the saturation point and weathering is more rapid than on the uplands. The mosses, lichens and shrubs which grow in abundance on the walls and talus slopes at the base of the cliffs, hold the moisture and aid in the process of rock decay. When first quarried the Black Hand sandstone is friable but on exposure to weathering becomes hard and durable. Usually the upper thickness of perhaps 5 or 10 feet of the Black Hand member projects prominently, forming overhanging ledges such as the roofs of Old Man's Cave and Ash Cave. It happens that the exposed top of the cliff becomes much harder by exposure to weathering, whereas the protected portion weathers away more rapidly, forming an overhang. Processes similar to those which are operating to form the gorges in Hocking County are also responsible for other scenic chasms, such as The Dells of the Wisconsin, Watkins Glen, Niagara George, Ausable Chasm and others.

OLD MAN'S CAVE PARK.

This is the most popular of the Hocking County group of parks and was selected by the Ohio Federation of Women's Clubs as the outstanding beauty spot in Ohio. The principal features are two caves, upper and lower Old Man's Caves,

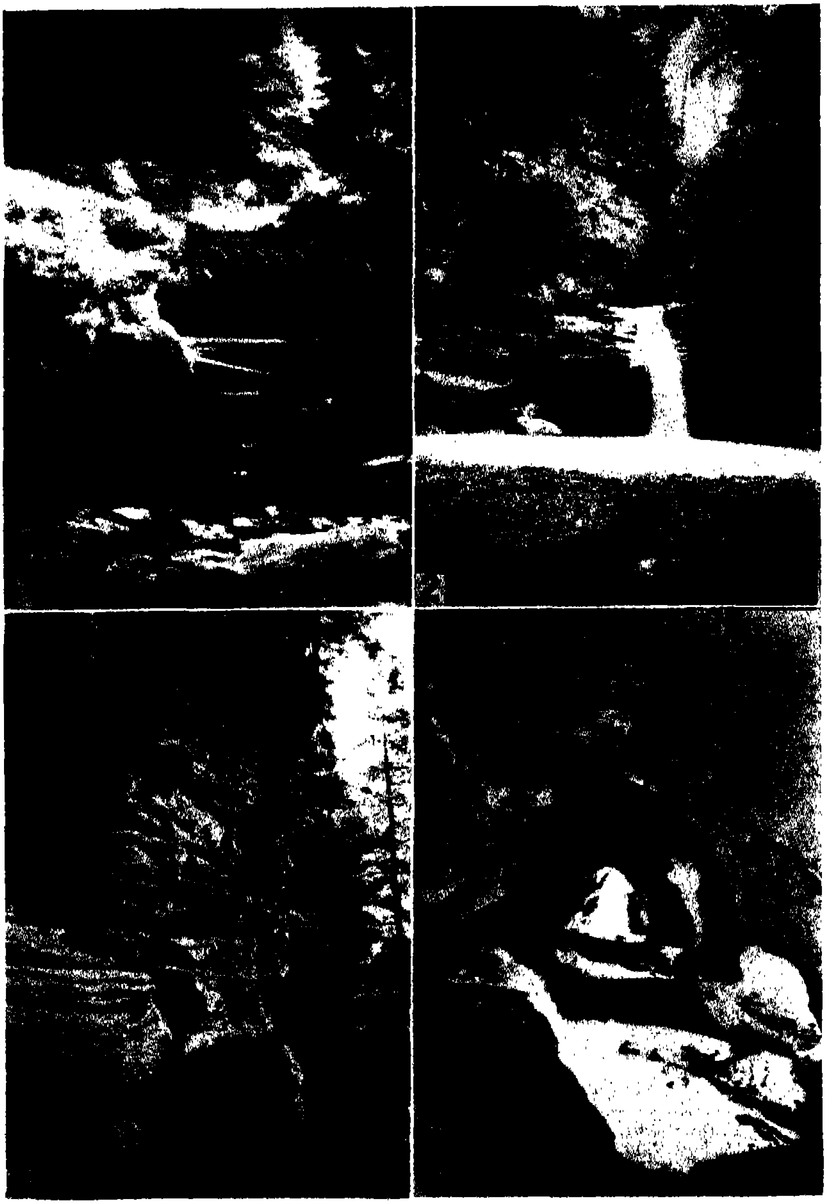

FIG. 1. Upper Old Man's Cave.
FIG. 2. Lower Old Man's Cave and Falls.
FIG. 3. Rock House Cliff.
FIG. 4. Interior of the Rock House.

picturesque waterfalls and two miles of heavily wooded gorge. The upper cave is located in a vertical cliff about 75 feet above the creek. Here a combination of weathering and erosion has produced an overhanging cliff. It is probable that the stream, when at the level of the cave, impinged upon the cliff and undermined it. Further deepening of the valley by the stream has lowered it below the level of the cave. The overhanging cliff at upper Old Man's Cave projects about 100 feet above the creek. The cave is not far from 200 feet long and 50 feet deep and has the form of a half-dome, a shape characteristic of all the caverns in the region. This is the form one would expect where streams have undermined a cliff and produced an overhang.

The gorge above and below the upper cave offers as fine an example of a glen as can be found anywhere. Giant hemlocks and hardwoods raise their leafy boughs above the gorge to the sunlight. The towering walls of the miniature canyon rise a hundred or more feet above the creek. Beneath the forest canopy are a profusion of ferns, shrubs and flowers, all of which add materially to the beauty of the valley. The width of the gorge above upper Old Man's Cave varies, widening and narrowing, from 30 to 50 feet. The upper gorge ends in a picturesque "cove," a semi-circular, overhanging cliff. The stream on the upland flows in a broad, shallow valley and falls over the sandstone ledge into the gorge below. A large, circular pool of water marks the pothole at the base of the falls. A cave, produced by the swirling water in the pothole at times of heavy rain, is present. The upper gorge ascends in places by rock benches, the stream descending by a series of falls or rapids.

Below upper Old Man's Cave, at a distance of perhaps a hundred yards, are the lower falls and lower Old Man's Cave. Here the water falls a distance of 30 to 40 feet to a pothole below. The cave is not far from 200 feet long, 50 feet wide and 40 to 50 feet high. There is evidence that in time of heavy rain, the water at the base of the falls accomplishes the undermining which produced the cave. The pool in the pothole is approximately 50 feet in diameter. The combination of waterfall, towering precipitous cliffs, mirror-like pool and cavern with the added beauty of the forest, make it easily the most scenic spot in the region. Below the lower falls the gorge is considerably wider and deeper than above. The stream has a small floodplain near its mouth and the benches over which

the creek flows are not so conspicuous. Great heaps of talus, composed of enormous blocks of sandstone and conglomerate, have accumulated at the base of the towering cliffs. On the whole the lower gorge is perhaps less scenic than the upper one. A very pleasant walk is possible by following the trail down the lower gorge and up Cedar Falls valley to Cedar Falls and across the upland back to Old Man's Cave.

CEDAR FALLS PARK.

Cedar Falls is located at the head of a gorge the stream of which flows into Queer Creek. There is the characteristic semi-circular cliff over which the water falls a distance of 50 or more feet, a pool at the base of the falls and a cave produced by pothole action. The gorge below Cedar Falls is similar to the one at Old Man's Cave, in fact it is really an extension of Old Man's Cave Park. It is possible to walk by trail from Old Man's Cave through an attractive, heavily wooded valley to Cedar Falls.

ASH CAVE.

Ash Cave is perhaps not the most beautiful spot in the region, but it is by all means the most spectacular. The ravine or gorge is short and ends in a gigantic cavern. A stream flowing in a broad, shallow valley on the upland, dashes over a semi-circular, projecting cliff or overhanging ledge of sandstone which forms the roof of the cave, to the bottom of the gorge a hundred feet below. The cave is approximately 700 feet long, 100 feet wide and 90 feet high. The origin of the cavern is not unlike the others in the area. The projecting ledge of sandstone which forms the roof of the cave is more resistant to weathering than the more protected beds of sandstone and conglomerate beneath. At times, during periods of heavy rainfall, pothole action is an important factor in undermining the cliff. The water sweeps away the accumulated debris at such times when the floor of the gorge is covered with water. When there is sufficient water in the stream, the falls are beautiful and in winter the ice formations are well worth seeing. The gorge is heavily wooded and very attractive.

ROCK HOUSE.

Many would call this celebrated natural feature the most interesting and unique in Ohio, a natural jewel in a splendid setting. It is not only unique but spectacular as well and

FIGURE 5. Conkle's Hollow.

FIG. 6. Ash Cave.

FIG. 7. Cedar Falls.

travelers say there is nothing just like it in this country. It is one of the best known of all natural attractions in Ohio and has been a popular beauty spot in Hocking County for more than a half-century. It is a house hewn out by nature from a wall of solid sandstone and conglomerate, 150 feet high. The Black Hand sandstone is here displayed at its best, a towering, overhanging cliff rising vertically from the gorge below. It shows the bright color where freshly exposed, red and brown where weathered and green where covered with moss and lichens.

The cave is about 200 to 225 feet long and varies from 25 to 30 feet in width at the level of the floor and is approximately 25 to 30 feet high. In most caverns the entrance is a narrow aperture, but here the sandstone has been weathered along the joints, forming a long corridor, opening out at the ends in two gothic doorways, at a point about half the height of the precipice. Along its front, enlargement of the joints by weathering has produced large sandstone pillars, the portals between them serving as windows. Nature has carved a gothic hall with windows and columns to bear the weight of the massive roof. There are five pillars and seven openings, the former being widest at the top, varying from 15 to 40 feet in diameter and from 15 to 20 feet in height. They are very irregular in shape, the result of differential weathering. The irregular outline of the windows stands out sharply against the more luminous background of the forest, as viewed from the darkness of the cavern. Each window is located along a large joint where weathering has been most effective. The joints are everywhere visible and can be easily traced from the windows along the roof and into the wall which forms the rear of the cave. The same process of weathering which formed the windows is at present taking place on the rear wall of the cave. Enlargement of the joints has produced vertical clefts in the wall, the blocks between standing out in bold relief. One set of vertical joints extends at right angles to the face of the cliff and breaks the sandstone into blocks 15 to 40 feet in width. Another set extends at right angles to the above mentioned set and runs parallel to the face of the cliff. Enlargement by weathering along one of these joints is responsible for the elongate corridor. This joint is very conspicuous along the roof and can be seen along the floor in some places. A cross-section of the cave at right angles to the cliff, gives an outline

like that of the gothic arch, wider at the floor, the walls converging upward and disappearing along the joint which runs the entire length of the cave. The end windows are located along this master joint. The cave is the product of differential weathering along two sets of master joints running at nearly right angles to each other. Where the cave is widest the sandstone crumbles readily and is more easily weathered than elsewhere. This is borne out by the hollows formed on the weaker sandstone on the back wall of the cave. In the grotto the well-bedded sandstone forms benches, one of which is about eight feet high and runs the entire length of the cave.

Rock House Park has other attractive features. It is possible to walk along trails which lead through the wooded country. A view from the fire-tower located not far from the Rock House gives one an excellent view of the surrounding region.

CONKLE'S HOLLOW.

Conkle's Hollow is not as well known and not as easily reached by good roads, but in some respects surpasses the other parks. It is different and has an individuality all its own. It is a deep rocky gorge, unimproved and nearer its original condition than some of the other areas. It is a wilderness, with great hemlocks and hardwoods and a profusion of ferns and shrubs in the moist, shady environment beneath. The canyon, if it may be so called, is wild and picturesque, with towering cliffs which rise more than a hundred feet above the floor. In some places the cliffs overhang and so narrow is the gorge that the writer estimated the distance at the top, from cliff to cliff, to be not more than 300 feet. Conkle's Hollow is most spectacular in winter when the cliffs are everywhere visible. The gorge is of unusual interest if one is prepared for strenuous climbing, to cover three distinct levels in the rocky hollow. The gorge ends abruptly in a "cove" similar to the others in the region already described. The valley narrows to a defile with almost unscalable cliffs at its head and ends abruptly in an overhanging ledge of sandstone. The cave is semi-circular in shape and not far from 50 feet long, 30 feet wide and 25 feet high. The water dashes into the cave from the upland through a cleft in the roof. A pothole, marked by a pool of clear water, occupies a large portion of the floor.

WEATHER CONDITIONS DURING WASHINGTON'S WESTERN JOURNEY OF 1770.

GUY-HAROLD SMITH.*

In the autumn of 1770 George Washington, at that time a distinguished planter living at Mt. Vernon, Virginia, made his most westward journey into the Ohio country.† On this "tour to the Ohio" he ventured westward into the interior of the continent when very little was known about systematic meteorology. He left Mt. Vernon on October 5 and returned on December 1, being absent from home exactly eight weeks and two days. While there was a chance that very disagreeable weather might be experienced, there was also the possibility that pleasant autumnal days, now known as Indian summer weather, might make the journey an enjoyable excursion.

Washington was not unfamiliar with the weather of autumn in the region of the Upper Ohio Valley, for in 1753, when he was sent by Governor Dinwiddie to deliver a communication to the French Commandant at Fort Le Boeuf, he experienced very severe weather before he returned. He set out on this journey the last day of October and was in the northwestern part of Pennsylvania during the latter part of December, and here he experienced very cold stormy weather. It was not until January 16, 1754, that he returned to Williamsburg, ending a long and tedious journey requiring two and a half months. Certainly it was, from the standpoint of weather, a poor time of the year for travel, but military expediency required that it be not delayed.

The journey of 1770 was begun a little earlier than the trip to the French post, when the country must have been most beautiful, for the forests would at that time change from verdant to the various colors of autumn. As the season advanced the falling of the leaves would facilitate the examination of the terrain, avowedly one of Washington's chief motives in making the journey.

*Member of the Ohio George Washington Bicentennial Commission.

†Guy-Harold Smith: "Washington's Camp Sites on the Ohio River," Ohio Archeological and Historical Quarterly, Vol. 41, 1932, pp. 1-19.

Washington, in keeping his diaries, included numerous notes on the passing weather, and it is from the record of October, 1770, that we can glean some information regarding weather conditions of that season. For this particular month he kept a separate record as a supplement to his longer journal.

The record of the weather is taken from Hulbert's transcription* of Washington's diary which he kept on his western tour. As a matter of fact he kept an extended journal which he entitled "Remarks and Occurs." in addition to the terse diary labeled "Where and how my time is Spent." His weather record is entitled "Acct of the Weather—in October" and is as brief as his diary. It appears that he did not keep a separate account for the remainder of his journey, but incorporated certain remarks about the weather in his journal.

Since his record for October, 1770, is fairly complete with an entry for every day, it is presented below in order to give continuity to the account. It is unfortunate that a more complete record is not available, but in these brief statements we have a valuable bit of information about the weather. His account is sufficiently detailed to permit an interpretation of the general distribution of the weather elements during the month of October.

"Acct of the Weather—in Octobr."

Octr 1st Wind Southwardly and Warm with flying Clouds.—
2. Raining, Hailing, or Snowing the whole day—with the Wind Northerly Cold & exceeding disagreeable—
3. Clear but Cold—Wind being very high from the Northwest—
4. Clear and pleasant—Wind being fresh.—and very fresh.—
5. Clear, Warm, & remarkably pleasant with very little or no Wind
6. Again clear and pleasant still
7. As pleasant as the two preceeding days
8. Pleasant *forenoon*—but the Wind Rising about Noon it clouded & threatned hard for rain—toward Night it rained a little & ceased but contd Cloudy
9. Exceeding Cloudy & heavy in the forenoon and constant Rain in the Afternoon
10. Cloudy with Rain & sunshine alternately.
11. Wet Morning with flying Cloud afterwards—toward the Evening the Wind sprung out at No West—
12. Rain in the Night with flying Cloud accompanied with a little Rain nw and then all day—cold & Raw—
13. Clear and pleasant Wind tolerably fresh from the Westward all day
14. Very pleasant but Wind fresh in the Afternoon.
15. Exceeding Cloudy & sometimes droppg. Rain but afterwds clear
16. Frosty Morning—but clear and pleasant afterwds clear
17. Exceeding warm & very pleasant till the Evening then lowering
18. Misty & Cloudy in the Evening the Forepart of the day being very warm
19. Misty & cloudy all day

*Archer Butler Hulbert, Washington's "Tour to the Ohio" and Articles of "The Mississippi Company," Ohio Archeological and Historical Society Publications, Vol. XVII, 1908, pp. 431–488. Transcription on pp. 448–449.

20. Misty—but the Evening clear tho somewhat Cool—
21. Cloudy & very raw & cold in the forenoon—about Mid-night it began to Snow & contd to do so—more or less all the remaing part of the Night & next day
22. Very raw & cold—Cloudy & sometimes Snowing. & sometimes Raining
23. Exceeding Cloudy and like for Snow—& sometimes really doing so—
24. Clear & pleasant Morning but Cloudy & Cold afterwards
25. Rain in the Night but clear & warm till abt Noon—then Windy & Cloudy
26. Clear and pleasant all day
27. A little Gloomy in the Morning but clear, still, & pleast afterwards
28. Much such a day as the preceeding one
29th Pleasant forenoon & clear but Cloudy and Wet afternoon.—
30. Raining in the Night—Raw cold & cloudy forenoon but clear & pleasant afternoon
31. Remarkably clear & pleasant with but little wind—

It appears from this account that Mt. Vernon, on the first day of October, 1770, was experiencing the typical warm weather at the front of an approaching cyclone. The next day brought rain and snow, indicating that the cyclone was a well developed storm. Such a storm certainly was more or less unusual as compared with present weather conditions, for it was early for snow in tidewater Virginia. The thermal gradient must have been unusually steep, for Washington describes the winds as warm on the 1st of October and they must have been particularly strong, for he observed that the clouds were flying, certainly indicative of winds of moderate velocity at least. On the second day the winds were northerly and cold. With snow falling the temperature must have fallen to near freezing, though it would not be necessary that the surface temperature be at 32° F. The ground so early in the autumn would still be warm, therefore the lower stratum of the atmosphere would be slightly above freezing. Such a blustering snow squall* is usually one of the first signs of approaching winter and unless it is followed by the cold weather which is sometimes the accompaniment of a stagnant anticyclone there is little danger of frost. Such storms are usually associated with well developed cyclones of autumn and may last from one to three or four days.

The average date of the first killing frosts† of autumn in the vicinity of Mt. Vernon is between October 21 and November 1. Only twice in the 20 years between 1895 and 1914 did the date of the first killing frost occur 15 days earlier than the average. From this record, made with modern

*Charles F. Brooks, "Why the Weather?" New York, 1924, p. 175.

†William Gardner Reed, "Frost and the Growing Season," Section I, Atlas of American Agriculture. Washington, 1920, p. 35.

instruments, it is clear that the Mt. Vernon section of tidewater Virginia experienced a cold snap somewhat earlier than is usual for that region.

The storm which brought snow to Mt. Vernon moved rapidly eastward bringing the area into the cold western portion of the cyclone. The center of the disturbance must have passed almost directly over Mt. Vernon or to the southward, for Washington notes that the wind was northerly. The following day, October 3, it changed to the northwest, indicating a continued eastward movement of the center. On the 4th of October the winds were still "fresh—and very fresh," but the sky was "clear and pleasant" just as we would expect under anti-cyclonic conditions which follow a cyclonic disturbance.

It was on the 5th of October that Washington, Dr. James Craik, a personal friend of his, and their servants set out for Fort Pitt, from which point they intended to embark on their extended journey down the Ohio to the mouth of the Kanawha River. The day was unusually pleasant, for Washington states that it was clear and warm with very little wind. His description of the weather for that day in relation to the conditions which preceded is indicative of high barometer. The sky was clear with very little wind and the next two days brought the same kind of weather. The area of high pressure must have been rather stagnant, tending toward maintaining clear weather for three or more days.

The fair weather ended for Washington on the eighth of October, but he had set a rapid pace and was by that evening well beyond the Shenandoah Valley. On that day the forenoon was fair, but in the afternoon the sky clouded up and in the evening it rained a little. Washington does not give any information about the wind and the temperature, so we cannot be sure that the change in weather was due to an approaching cyclonic disturbance or to a local convectional storm. Since he does not mention thunder and lightning, but does speak of the cloudy condition, particularly on the 9th, when it was "Exceeding Cloudy & heavy in the forenoon," it appears that the eastern part of another well developed storm was extending the eastern border and its accompanying cloud area over the country being traversed by Washington. In the afternoon of the ninth a continuous rain is an additional feature which lends plausibility to the interpretation made above. On the tenth the rain alternated with sunshine, but the morning of the

eleventh was wet. By the afternoon the storm center passed and toward evening the wind came out of the northwest. This is the first time Washington had recorded the direction of the wind since the third, thus we may conclude that the coolness probably moved him to make a note on its direction.

He recorded that the twelfth of October was "cold & Raw" with the wind out of the northwest. The storm had advanced eastward and Washington was again experiencing the cold northwest winds and the accompanying weather conditions characteristic of the westernmost portion of the cyclonic storm of autumn. He must have been reminded of the cold, bitter days which he endured on his journey to Fort Le Beouf in the autumn of 1753.

The wind had changed to westward by the 13th of the month, suggesting that the storm center was advancing toward the northeastward, or it may mean that the normal westerly or southwesterly winds were being established as the cyclonic disturbances became farther removed from southwestern Pennsylvania, the region then being traversed by Washington. It was on this date that he passed over ground familiar because of his engagement with the French at Fort Necessity in 1754. Curiously enough Washington did not commit to paper any reminiscences on his unhappy experiences here. In his journal he wrote briefly about the land and the weather. On the evening of the 13th he arrived at the home of William Crawford, his western agent, who accompanied him on his journey down the Ohio and later surveyed land for him upon the Ohio and Kanawha Rivers.

The fourteenth was also pleasant, the wind freshening in the afternoon, but Washington failed to note the direction. In view of the weather of the following day it is logical to assume that the wind came from a southerly or easterly quarter, presaging the eastward movement of a low pressure area which was then centered somewhat to the westward. The fifteenth was cloudy with occasional but light rain. It is probable that the storm center had moved eastward bringing the area south of Fort Pitt into the southern portion of the cloud cover. In the evening it was clear, permitting nocturnal radiation to lower the temperature to near freezing, for the morning of the 16th of October was "frosty." It was clear that day and later in the afternoon the weather was pleasant. The cyclonic disturbance had moved onward and the day was ideal for the

business Washington had to discuss with Crawford. By evening he was again on his way toward Fort Pitt.

By the 17th of October another storm was approaching, for the day was "Exceeding [ly] warm & very pleasant." Washington does not give the direction of the wind, but the fact that the day was very warm lends plausibility to the assumption that warm air was being imported from the southward as another area of low pressure moved eastward toward western Pennsylvania. He described the evening as "lowering," an expression sometimes used to describe a heavily overcast sky.

The next day it was very warm in the "Forepart," but by evening it was cloudy and misty. This inadequate report on the weather makes it difficult to guess the distribution of the weather elements, but the weather of the 18th seems to have been that which accompanies an autumnal disturbance which is not sufficiently developed to bring heavy precipitation. The storm probably advanced slowly, for the 19th was also "misty & cloudy," and even the 20th continued misty. In the evening, however, the sky cleared and the weather became cool. The sequence of weather events is rather convincing that again Washington, on the day he began his journey down the Ohio River, was experiencing the cool weather which usually follows the passing of a cyclone of autumn.

From his account it is not unreasonable to interpret the weather in terms of the conditions that are related to the more or less regular movement of the low pressure areas eastward across the United States at a season of the year when the tracks followed by these storms lie somewhat southward of the more frequented paths of the summer months. It appears that during Washington's long journey into the interior of the continent of North America several well developed cyclones passed far south of the Great Lakes and as they moved forward brought unseasonably cool autumn weather southward to the latitude of Ohio and Potomac Rivers.

As mentioned above the cold weather accompanying a cyclone greeted Washington as he began his descent of the Ohio River on the 20th of October. For the next five days ill weather was his fortune. It rained and snowed almost every day. He does not mention the direction of the wind, so we are unable to make more than a guess at the general weather conditions. On the 21st it was "very raw & cold" and on the 22nd he made the same notation in his weather

record. The weather had not improved much by the 24th except that it was "clear & pleasant" in the morning. It was cloudy and cold later in the day, but there is not enough information to permit a detailed discussion of the general weather conditions. The long period of cold, raw days seems to indicate that a cold mass of air was spreading southward mixing with a warmer stratum producing in the latter and at the zone of contact sufficient condensation for a heavy cloud cover, but not enough to produce heavy precipitation. The weather conditions were not sufficiently severe to impede the progress of Washington's party, for by the 22nd of October they were 75 miles below Fort Pitt, and also he makes no comments about the river or the tributaries which would indicate that conditions were unusual, except that he recorded on the 22nd that the water was "pretty swift" in places.

The 23rd of October was a rather unpleasant autumn day. He remarks that it was "Exceeding Cloudy & like for Snow— & sometimes really doing so —." The 24th was a little better "Clear & pleasant Morning but Cloudy & Cold afterwards." On the 25 there was "Rain in the Night but clear & warm till abt Noon—then Windy & Cloudy." It seems that during this three day period the approach of autumn was being heralded by cold cloudy weather as the moisture content of the atmosphere was being reduced.

On October 25th Washington noted the effects of a wind storm of earlier date. Some miles below Wheeling he came to a stream entering the Ohio from the west, which the Indians called "broken Timber Creek;* so named from the Timber that is destroyed on it by a Hurricane; . . . ." It is interesting to note Washington's use of the term, hurricane. On his voyage with his half-brother, Lawrence, to the Barbadoes in the autumn of 1751 the ship was caught in a severe storm and Washington wrote in his journal on October 19th that "It was universally surmis'd their had been a violent hurricane not far distant." He was not unfamiliar with winds of hurricane velocity.

The stormy weather which Washington experienced on the first six days on the Ohio River soon changed for the better. He was now down nearly as far as the site of Marietta, Ohio. On the night of October 26 he camped just above the mouth of the Little Muskingum where Reno is now located. It was

*Probably Sunfish Creek.

"Clear and pleasant all day." In his extended journal the final paragraph of his entry of October 26 reads "This day provd clear and pleasant, the only day since the 18th that it did not Rain or Snow, or threaten the one or other very hard."

On the 27th he continued down stream. It was "A little Gloomy in the Morning but clear, still, & pleast afterwards," and the 28 was "Much such a day as the preceeding one." The three successive days of pleasant weather indicate that anticyclonic conditions were in control. It is regrettable that Washington failed to record the wind direction so that his position in respect to the pressure areas could be determined.

On the 29th of October Washington rounded the Great Bend and ran into another storm area, or considering his rate of travel, a storm area ran into him. A day described as having a "Pleasant forenoon & clear but Cloudy and Wet afternoon—" was his lot. Of the 30th he wrote, "Raining in the Night— Raw cold & cloudy forenoon but clear & pleasant afternoon." The last day of October was "Remarkably clear & pleasant with but little wind." During the last three days of October he had passed through a storm area into the clear fair weather of an anticyclone. The order of the weather phenomena makes this assertion very plausible.

His systematic record of the weather was concluded with his entry of October 31 but from his journal we may glean a few statements which give some information about the weather during the month of November, 1770. The quotations in the remainder of this paper are taken from Fitzpatrick's transcription* of Washington's journal. His record is devoted to other matters hence his remarks on the weather are incidental and so limited that it is next to impossible to discuss in detail the general distribution of the weather elements.

During the first four days of November he made no comment on the passing weather, but on the 5th, the day he walked across a strip of bottom land below the Great Bend† and camped some miles up stream. He concludes his entry for that date with " . . . we Incamped, the afternoon being rainy, and the night wet." Again it appears that a storm of autumn had overtaken him.

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*John C. Fitzpatrick, "The Diaries of George Washington, 1748–1799," Vol. I, Boston, 1925.

†Guy-Harold Smith, "George Washington at the Great Bend of the Ohio River," Ohio Archeological and Historical Quarterly, Vol. 41, 1932, pp 655–667.

For the next three days, November 6, 7 and 8, the weather conditions go unrecorded. The journal from the 7th to the 16 has been mutilated along the edges, so his record is incomplete and can be interpreted only by considerable interpolation. The 8th of November must have been a fine day for Washington, Crawford and an Indian guide explored the hills above the mouth of the Little Kanawha and that night camped about a mile below the mouth of the Muskingum. His entry for the 9th begins with "The Night prooving very Rainy, and Morning wet we did not set out till ½ after 10 Oclock . . ." Nearly all of his entry for Saturday, November 10th was devoted to the weather. He wrote, "After a Nig[ht] of incessant Thunder and Lig[ht]ning, attended with heavy [con-] stant Rain till 11 Oclock [that] day, we set of about Twelve (the Rain then ceasing) and [came] to the lower end of the long [reach]* distant about 12 Miles—little stream, imperceptable [to] the view in our passage [down but] now pouring in her mite, ... River raising very fast [and] grows so muddy as to ren[der] the water irksome to drink" The "incessant thunder" was a little late in the season, but not an unusual occurrence. It indicates that the temperatures were not unseasonably cold, and perhaps a little above normal.

The stormy weather continued, impeding Washington's upstream journey. For Sunday November 11th he wrote that, "The last Night proved a Night of incessant Rain attended with thunder and lightning. The River by this Morning had raisd abt . . . feet perpendicular and was [trav]elling fast. The rain seeming [to] abate a little, and the wind spring[ing] up in our favor we were [te]mped to set of; but were deceived [in] both; for the Wind soon ceasd, and [the] Rain continued without inter[mis]sion till about 4 Oclock when it moderated." In spite of the rain they got to the head of the long reach, but the stormy weather and the strong current made upstream travel very slow and arduous.

The stormy weather continued yet another night. On the 12th he recorded that "There fell a little [rain] in the Night tho nothing to [speak] of." The river was so swift that Washington gave up trying to paddle the canoe all the way to Fort Pitt, and on the next day sent a young Indian

*The word "reach" is supplied by the present writer for it was on this date that Washington and his party had arrived at the sixteen mile section of the Ohio River commonly known as the "long reach."

to bring their horses to Mingo Town, two miles below the modern Steubenville. At Mingo Town he had to wait three days for the horses to arrive, but on the afternoon of the 20th the party set out for Fort Pitt which they reached the following day.

During the period from November 13 to 23 inclusive Washington made no direct statement* about the weather. He does state that the level of the river was falling on the 17th, so we may conclude that the rainy spell was over.

It was on the 23 of November that he set out on his journey from Fort Pitt to Mt. Vernon. The next day he arrived at Captain Crawford's, and his brief entry for that date is concluded by the expression, " . . . it either Raining or Snowing hard all day." It is to be expected that snow might fall in the Allegheny plateau of southwestern Pennsylvania in the latter part of November.

On Sunday, November 25 Washington continued his journey and set out early to visit Lund Washington. He made no definite statement about the weather but noted that " . . . the Ground and trees being coverd with Snow . . . " he was unable to form a distinct opinion of the quality of the land. On the 26th he recorded that "The Snow upon the Alligany Mountains was near knee deep." It is clear that snow in considerable quantity had come early to the highlands of the Allegheny Mountains. Here where Washington found the snow nearly a foot deep toward the end of November the average date of the first killing frost* of autumn is about October 1. It is not an uncommon occurrence to have snow in the higher parts of the plateau any time during the month of November, so the weather experienced by Washington was not unseasonably cold. It is a little unusual, however, to have a foot of snow by the 23 of November.

Washington required five more days to reach home arriving at Mt. Vernon on December 1, 1770. He had been gone just four days short of two months, and during that time had made his most western journey into the heart of North America and travelled altogether a distance of nearly 1000 miles. His weather records for this period indicate that the autumn of 1770 probably was characterized by fairly typical cyclonic storms which brought a snow squall to tidewater Virginia the first of October. During that month probably a half dozen

*Reed, Op. cit., p. 35.

distinct cyclonic disturbances can be identified and their movements determined with some degree of accuracy.

Washington certainly had very little systematic knowledge of the passing weather, but his empirical descriptions make it possible to interpret and explain the meteorological phenomena in terms of the modern knowledge of the science of the atmosphere. The well developed cyclonic storms, the origin of which we are not certain but the nature of which we know much more, brought to Washington and his party changeable autumn weather. He faithfully recorded his observations and these now serve as documentary source material for the study of historical meteorology.

The Social Life of Plants.

Although the name was coined in 1896, the term "plant sociology" may arouse some new concepts in the minds of those who have not been accustomed to consider plant life in terms of communities or social units. The original German text, "Pflanzensoziologie," which appeared in 1928, has been entirely translated, revised, and edited with the addition of considerable new material.

Part I consists of a single chapter on "Social Life Among Plants." Part II contains three chapters on the organization of plant communities. The selection of sample plots for study and the statistical analysis of plant communities are some of the important topics discussed. Methods are given for the determination of abundance, cover, space, and weight of species concerned, as well as such characteristics as sociability, periodicity, frequency, constancy, and fidelity of species. The technical sense in which these terms are applied to plant communities is explained in the text.

Part III includes eight chapters (more than half of the entire book), which discuss the general subject of synecology or "community economics." Here there is an attempt to "search for the underlying causes of the social union and the mutual dependence of the component plants." Factors of climate, soil, topography, and the activities of man and grazing animals, as they affect plant communities, are extensively treated. There is much illustrative material from the works of European and American investigators. Practical methods devised for field use are described in this section of the book.

Parts IV, V, and VI consist of the final three chapters on the development, distribution, and classification of plant communities respectively. An extensive bibliography and index complete the volume. Halftones and line drawings are clear cut and are well-chosen to present data in graphic form.

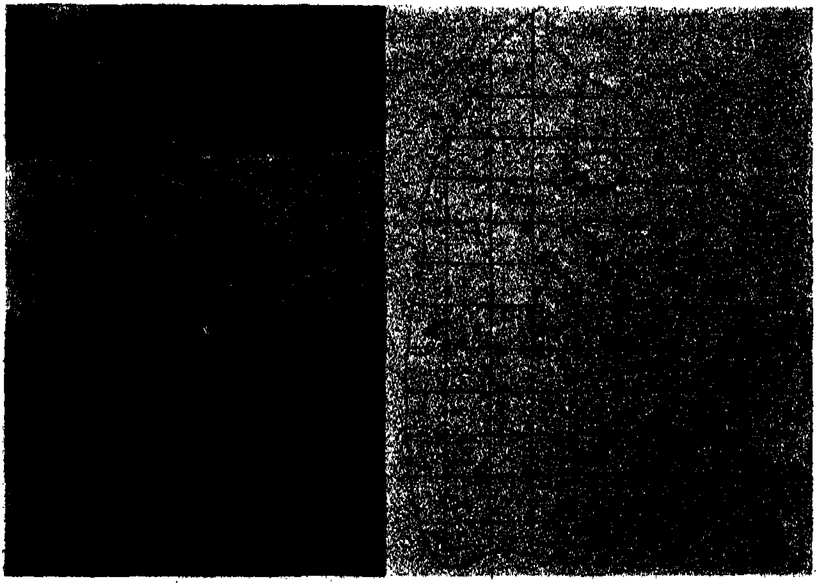
The use of such terms as "Quercetum" for oak forest and "therophytes" for annual plants show that the author and the translators have accepted European systems of nomenclature for plant communities and life forms. With such a terminology, books and papers on plant sociology appear as difficult reading for the general botanist as the literature on psychiatry must appear to the general practitioner of medicine. Perhaps it is a sign of progress in a science when its language becomes more cumbersome.—R. B. GORDON.

Plant Sociology, by J. Braun-Blanquet. Translated, revised, and edited by G. D. Fuller and H. S. Conard. XVIII — 439 pp., 180 figs. McGraw-Hill Book Co., 1932.

NOTES ON ANOTHER PENNSYLVANIAN FOOTPRINT FROM OHIO.

ROBERT H. MITCHELL,
Muskingum College.

At the 1931 meeting of the Ohio Academy of Science at Oxford, Ohio, a paper entitled "Fossil Footprints from the Pennsylvanian of Ohio" was presented and subsequently published (1). The paper described the finding of "a remarkable number of fossil footprints all apparently made by the same type of animal," in the Cleveland mine of the Cambridge



Collieries at Senecaville, Guernsey County, Ohio. These tracks were identified as those of *Ancylopus ortoni* Carman. Since they were found in the shale above the Upper Freeport coal this was a new locality for *Ancylopus ortoni*. "The striking thing about this locality is the great abundance of tracks, all apparently made by the same type of animal."

Since the publication of the paper a slab which was obtained from the same locality and which is now in the collection of

Muskingum College has been found to show another type of track. This slab is 19 x 24 inches and shows 9 tracks or parts of tracks. (Figure 1.) The tracks consist mainly of what seems to be prints of the ends of the toes and in some cases a broad shallow imprint of the heel as is shown in Figure 2, which is a scale drawing of the slab. The heel prints are seen best on what appears to be the pes. The prints show that the animal which made them had a plantigrade foot with five toes.

Unfortunately, these tracks are not well preserved and absolute identification is impossible from this slab. A careful study has shown a close resemblance to *Baropus hainesi* Carman (2) and it is quite probable that the prints were made by that animal. If this identification is correct this is a new locality both geographically and geologically for *Baropus hainesi*, the original tracks being found in the Pennsylvanian system, Monongahela formation beneath the Benwood limestone in Center Township, Morgan County, Ohio.

As far as the writer knows these are the only tracks other than *Ancylopus ortoni* from this locality. While search is being made for other tracks of this nature with the hope of positive identification, it was thought advisable, in the light of the new finding, to supplement the previous publication and bring it up to date.

LITERATURE.

1. **Mitchell, R. H.** Ohio Journal of Science, Vol. 31, No. 6, November, 1931. pp. 501–504.
2. **Carman, J. E.** Bulletin of Geological Society of America, Vol. 38, June 30, 1927. pp. 386–388.

All About Chromosomes.

This is by far the most complete discussion of chromosomes and their importance in evolution to appear in recent literature. It is fascinatingly written, and is authoritative as well, coming from the pen of one who has published continuously on genetics since the beginning of the century. The normal behavior of chromosomes, the localization and mapping of genes, the translocations and deficiencies of genes, the abnormal behavior of chromosomes and the formation of polyploid species and varieties are all discussed in a most interesting and readable style. The choice of illustrations is to be especially commended, each topic being illustrated from the original sources in the fullest possible manner. The recent work on experimental mutations and transmutations is discussed, and the gene as the basis of life and evolution is investigated. A chapter is given to the question of genes in the protozoa. In all, the book is a worthy and necessary addition to any scientific library.—L. H. S.

The Mechanism of Creative Evolution, by C. C. Hurst. xxi + 365 pp. Cambridge, at the University Press (In U. S. A., The Macmillan Co.), 1932.

THE INHERITANCE OF ISO-HEMAGGLUTINOGENS IN RABBITS.

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The search for true blood groups in animals, corresponding to the four orthodox groups in man, has not met with much success. (Snyder, 1926, 1929). In 1929, however, it was independently discovered by Levine and Landsteiner and by Fischer and Klinkhart that the blood of rabbits may possess agglutinogens for which no normal agglutinins occur. Immune agglutinins may be produced for these, however. When such immune agglutinins are produced, it is possible to separate rabbits into groups according to whether or not they possess a particular agglutinogen.

The two agglutinogens discovered by Levine and Landsteiner, and Fischer and Klinkhart, respectively, were found on comparison not to be identical. Thus, some rabbits possess both agglutinogens, some only one, some the other, and some possess neither. On this basis rabbits are of four groups.

The inheritance of these groups becomes at once of interest to the genetecist. Many genetic characters are known in rabbits, and the occurrence of a new factor makes possible the extension of linkage results. Rabbits of known group were accordingly sent by Landsteiner to Castle for genetic study. It was suggested by Castle that we cooperate in the work, the final plan being to produce the Fischer serum at Ohio State and study its agglutinogen at that institution, and to produce the Landsteiner serum at Harvard and study its agglutinogen there. In 1930 we received at the Genetics Laboratory of the Ohio State University five rabbits, two of them known to contain the Fischer agglutinogen (i.e., positive), and three known not to contain it (negative).

Our first task was to obtain a diagnostic serum. With the kind assistance of Dr. C. A. Doan we were able to produce a strong agglutinin by immunization. The method used was as follows.

Aseptic technic was used throughout. Nine cc. of blood were withdrawn from the heart of the donor (known to be

positive) into a syringe containing 1 cc. of 5 percent sodium citrate in normal saline. The donor was not anaesthetized, but was held on its right side by two assistants. With the rabbit's head at the left of the operator, the heart was located by the operator's thumb, the hair shaved from over the heart, alcohol and iodine applied, and the needle pushed between the ribs. With a little practice the needle can be inserted into the ventricular cavity and blood withdrawn.

TABLE I.

SUMMARY OF 77 FAMILIES OF RABBITS STUDIED FOR THE PRESENCE (POSITIVE) OR ABSENCE (NEGATIVE) OF AN ISO-HEMAGGLUTINOGEN.

MATINGS	OFFSPRING	
	Positive	Negative
positive x positive 40	124 calc. .880 obs. .893 dev. .003	15 .110 .107 .003
positive x negative 33	85 calc. .668 obs. .692 dev. .024	38 .332 .308 .024
negative x negative 4	0 calc. 0.00 obs. 0.00 dev. 0.00	13 1.00 1.00 0.00

The citrated blood was then injected directly into the marginal ear vein of the recipients (which were negative for the agglutinogen). The 10 cc. of citrated blood were divided among two recipients. Two donors were used alternately. The injections were made every four days until nine had been made.

After the last injection, the serum of the recipients was tested against the red cells of the donors. It was found that a strong agglutinin had been produced in the serum of the recipients. Fourteen days after the last injection, the recipients were exsanguinated, and the serum prepared and stored with a preservative.

It was then possible to test all our available rabbits for the presence or absence of the agglutinogen. A drop of a washed suspension of red cells was mixed with a drop of test serum on a slide, in a manner similar to the test for the human blood groups. The slides were examined at the end of a few minutes, and again at the end of an hour in the incubator.

In all 504 rabbits were tested; of these 379, or 75.1% were positive, and 125, or 24.9% were negative. Of these 504 rabbits, 429 were studied from the standpoint of heredity. They comprised 77 families of parents and offspring. The results of this study are given in Table I.

The agglutinogen appears to be a dominant unit character. It is seen, however, that the observed numbers of negative offspring in the crosses of positive with positive, and positive with negative, are slightly less than the calculated results. This suggests the possibility of another allelomorph.

The calculated results were obtained by the formulae

$$\left(\frac{q}{p + 2q}\right)^2 \text{ and } \frac{q}{p + 2q}$$

as developed by Snyder (1932). In the case of this agglutinogen, letting H stand for the factor producing the agglutinogen and h for its absence, and setting p as the frequency of H and q as the frequency of h, $p = .502$, and $q = .498$.

It can readily be shown that the above formulae will give the expected results if only two allelomorphs are concerned, but will give results somewhat higher than those to be expected if three allelomorphs exist. Thus in the four human blood groups, assuming that only two groups, A and O, are known (in which case group AB would be included with A, and B with O),

$$\begin{aligned} &\text{Let } p = \text{frequency of A} \\ &\text{and } q = \text{frequency of O} \\ &p^2 + 2\,pq = \text{group A} \\ &q^2 = \text{group O} \\ &q = \sqrt{O} \end{aligned}$$

Since the real group O occurs with a percentage of 45 in the American population, and group with B a percentage of 10, our supposed group O will here be .45 + .10. Then

$$\begin{aligned} q &= \sqrt{.55} = .741 \\ p &= 1 - q = .259 \end{aligned}$$

When, however, the four groups are actually known, due to three allelomorphs A, B and O, we may let p = frequency of A, q = frequency of B, and r = frequency of O. Then p + r, dealing with the frequencies of the factors concerned in groups A and O, will be less than 1. The derivation of p, q and r has been dealt with in previous publications (Snyder 1926, 1929 etc.).

Let R = % recessives expected in matings of A with A when only two groups, A and O, are known,

And let R^1 = % recessives expected when four groups are actually known.

Let S = % recessives expected in matings of A with O when only two groups are known,

and let S^1 = % recessives expected when four groups are known.

$$\text{Then } R = \left(\frac{q}{p + 2q}\right)^2$$

$$R^1 = \left(\frac{r}{p + 2r}\right)^2$$

$$S = \frac{q}{p + 2q}$$

$$S^1 = \frac{r}{p + 2r}$$

These formulae may be applied to the known proportions of the four blood groups and the derived frequencies of the genes in man. Using Americans and Koreans, as representing two races where the allelomorph B is low and high, respectively, the results are as given in Table II.

TABLE II.

COMPARISON OF PROPORTION OF RECESSIVE OFFSPRING TO BE EXPECTED IN VARIOUS MATINGS WHEN ONLY TWO OF THREE ALLELOMORPHS ARE KNOWN, AND WHEN ALL THREE ARE KNOWN.

	AMERICANS	KOREANS
R	.180	.190
R^1	.175	.173
S	.425	.436
S^1	.419	.416

It is seen that when only two allelomorphs are known of a series containing more than two, the recessive offspring observed in matings of dominant with dominant, and dominant with recessive, will be less than that calculated on the basis of two allelomorphs. We find this condition to exist in our results. While the differences are small, they are both in the same direction, and only a small difference is to be expected.

Inasmuch as Castle and Keeler are investigating the Landsteiner agglutinogen, and tell us that they find it to be due to a dominant factor similar to the one producing the Fischer agglutinogen, (Castle and Keeler, in press) we predict on the basis of our calculated results that the two will be found to be allelomorphs, forming with the recessive factor producing neither substance, a series of three allelomorphs, and thus four groups.

We have sent samples of our serum to Castle and Keeler for such a study, with the suggestion that matings between double positives and double negatives be especially examined as giving critical evidence on this point. Their results will be separately published.

We have also made numerous experiments on guinea-pigs, using a wide variety of donors and recipients, but have thus far been unable to demonstrate the presence of any agglutinogen in the red cells. These experiments are being continued.

SUMMARY.

1. The presence of an iso-hemagglutinogen in rabbits, originally discovered by Fischer and Klinkhart, behaves as a unit factor dominant over its absence.

2. The comparison of observed and calculated proportions of recessives in various types of matings leads us to predict the presence of a third allelomorph in the series, presumably the gene for the presence of the agglutinogen discovered by Levine and Landsteiner. This possibility is being investigated by Castle and Keeler as part of a cooperative project.

3. Attempts to demonstrate the presence of iso-hemagglutinogens in guinea pigs have thus far been unsuccessful.

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SOME NEW SPECIES OF EUGNATHODUS. (HOMOPTERA CICADELLIDAE).

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Eugnathodus Baker.

The genus *Eugnathodus* was erected in 1903 by Baker at which time *E. abdominalis* V. D. was cited as the type. From the description of the genus it is apparent Baker had in hand specimens of the species which we have since identified as E. *abdominalis* but which is given the name of *E. neglecta* in this paper. An examination of the type specimens of *E. abdominalis* has revealed the fact that they are specimens of *Balclutha* and it is apparent Baker cited this type in error. The type of *Eugnathodus* as described by Baker is therefore designated as *neglecta* Del & Dav.

This genus differs from *Balclutha* in having the vertex broadly rounded, almost parallel, margined, only slightly produced before the anterior margins of the eyes, and head broader than pronotum.

A forthcoming paper will deal with the species of this genus and *Balclutha* but in order that other workers may use these names in citing these species in other papers, the following descriptions are presented at this time.

Eugnathodus neglecta n. sp.

Usually pale or dark brownish in color with blunt head and distinct genitalia. Length, 3.5 mm.

Vertex almost four times as wide as long, broadly rounded, almost parallel margined. Pronotum three times as long as vertex.

Color pale to dark brown, often with rather conspicuous markings on vertex pronotum and scutellum. Elytra smoky to white.

Genitalia: Female last ventral segment with posterior margin slightly emarginate either side of a central slightly produced median tooth which is inconspicuous. Posterior margin narrowly embrowned. Male valve rounded posteriorly, plates triangular, about half as wide at base as long. Pygofers exceeding plates. Oedagus in lateral view rather heavy at base, anterior process extending dorsally, arising not far from the point of union with the connective. Body of oedagus extending caudally, tapered and extending dorsally and slightly posteriorly. Terminal portion about twice the length of the anterior process.

The species has been designated for many years as *Eugnathodus abdominalis* V. D., but examination of the type specimens have shown this to be a *Balclutha* and the species previously identified as *B. impicta* V. D. Also the species previously identified as *B. impicta* are pale specimen of *B. punctata*.

This species is very common and wide spread and occurs in many areas.

Described from a large series of specimens from several widely separated localities. Specimens have been examined and male genital characters checked for the following localities: Alturas Lake and Stanley Basin, Idaho; Glacier Park, Montana; Springer, Mesilla Park and Raton, N. Mex.; Tempe and Tuscon, Arizona; Tower City, N. D.; San Antonio, Paris and Brownville, Texas; Lincoln, Nebraska; Decatur, Ga.; Orlanda, Fla.; Rocky Ford and Mt. Manitou, Colorado.

Male holotype, Mt. Manitou, Colorado. Female allotype from same locality and male and female paratypes in author's collection. Paratypes in collection of U. S. National Museum and personal collections of Herbert Osborn and E. D. Ball.

Eugnathodus neglecta variety **pallida** n. var.

Form and general appearance of *neglecta*, but pale green or white in color. Length, 3 to 3.5 mm.

Structural and genital characters as in *neglecta*.

Color pale green or yellow, often appearing milk white. Disc of pronotum sometimes slightly darker. Dorsal portion of abdomen black or dark brown. Elytra whitish subhyaline unmarked.

Described from a series of specimens from Clarksville, Tennessee, collected during July and August, 1915, by the senior author.

This may be a separate species but cannot be distinguished on the basis of structural characters.

Eugnathodus floridana, n. sp.

Resembling *neglecta* in general appearance; pale green and with distinct genitalia. Length, 3 mm.

Vertex three times as wide as long and one-third as long as pronotum. Elytra produced one-third their length beyond apex of abdomen.

Color: Pale green marked with yellow. Elytra whitish subhyaline, veins white, claval area yellowish.

Genitalia: Female last ventral segment long, posterior margin roundedly produced, appearing to be notched at middle. Male genital

pieces with styles in ventral view broad at base, strongly narrowed to finger-like pointed apices which are divergent. Outer margin of style heavily chitinized on central portion and curved downward. Connective of oedagus more deeply notched at base than other species. Oedagus in lateral view thick at base with anterior portion extended, slightly forward, upward and then directed posteriorly. Body of oedagus extending dorsally and curving anteriorly into preceding segment.

Described from two female and one male specimens collected at La Belle, Florida, April 20 and 21, 1921 by the senior author. Holotype male La Belle, Florida, April 21, 1921. Allotype female and female paratype in collection of senior author.

Eugnathodus abbreviata n. sp.

Short and robust, pale yellow in color and with distinct genitalia. Length, 2.5 mm.

Vertex broadly rounded more than three times as wide as long. Produced two-thirds its length before anterior margins of the eyes. Pronotum three times as long as vertex.

Color: Pale yellow or white washed with bright yellow. Eyes usually dark brown. Elytra whitish subhyaline, claval area washed with yellow.

Genitalia: Female last ventral segment slightly produced and sinuate either side of a slightly produced median tooth-like portion. Male valve short and rather broad. Plates about one and one-half times as long as broad, apices blunt. Styles in ventral view rather long, wide at base, triangular, rather abruptly narrowed to divergent finger-like tips. Oedagus in lateral view with a long thick finger-like portion at base extending dorsally. Body of oedagus long and curved extending dorsally and with apex directed anteriorly.

The pale yellow color of this species and the distinct genital character of the male will easily distinguish it from the other species of the genus.

Described from a series of some seventy specimens, mostly females, collected at Belle Glade, Florida, during the summer of 1929 by Mr. Hugh Clifton. Holotype male, allotype female, and male and female paratypes in collection of senior author. Female paratypes in U. S. National Museum collection.

Eugnathodus calcara n. sp.

Resembling *neglecta* in form, size and appearance, but distinguished by the male genital characters and a large spine on the pygofers. Length, 3.5 mm.

Vertex broadly rounded three and one-half times as wide as long, produced about one-half its length before anterior margins of eyes.

Color: White to dull gray, vertex, anterior portion of pronotum and basal angles of scutellum ferruginous to yellow. Elytra white, venation white.

Genitalia: Male styles broad at base, concave inwardly on basal margin, tapered toward apex. Conspicuously, abruptly notched toward base on outer margin forming a thick finger-like apical process which curves outwardly from inner margin. Connective broad at base and broadly shallowly notched. Oedagus in lateral view thick at base with anterior basal process directed dorsally and anteriorly. Posterior portion extending into a long whip-like process which is gradually narrowed and directed dorsally and anteriorly at apex. Pygofers of male with a heavily chitinized spur arising at the ventral caudal portion and curving upwardly and inwardly into the genital chamber.

Described from two male specimens collected at Miami, Florida, April 14, 1921, by the senior author. Holotype male and paratype male, Miami, Florida, April 14, 1921, in collection of senior author.

The species can easily be distinguished from all others of the genus by the heavy spur on the pygofer.

Eugnathodus bifurcata n. sp.

In general appearance resembling *neglecta*, but with distinct male genitalia and a bifurcate spine on the pygofer. Length, 3.5 mm.

Vertex three and one-half times as wide as long, less than one-third as long as pronotum.

Color: Gray to dull green tinted with yellow, without definite color markings. Eyes usually dark.

Genitalia: Female last ventral segment with posterior margin almost truncate, slightly indented either side of middle. A dark brown color marking on middle of posterior portion causes the segment to appear deeply notched either side of a median broad rounded tooth. The male genital pieces are unique. Style concave inwardly at base, constricted about middle then enlarged to form a pair of finger-like processes by being deeply notched on outer margin. The basal one is heavy and short, the apical one is long and strongly curving outwardly. Oedagus in lateral view rather thick on basal half, without anterior process, terminal half curved and directed anteriorly from erect position of basal portion. Pygofer with a heavily chitinized spine extending into the genital chamber. A short chitinized spur also extends downward from the lower end of the large spine.

Described from a series of three female and four male specimens. The female and three male specimens were collected at Miami, Florida, April 13, and 14, 1921 and one male specimen at Paradise Key, Florida, April 5, 1921, all by the senior author. Holotype male, allotype female, and male and female paratypes in collection of senior author.

CICADELLIDAE LEAFHOPPERS OF NEW HAMPSHIRE.*

PHILIP ROSEMOND LOWRY.

THE CICADELLIDAE OF CERTAIN PLANT ASSOCIATIONS IN NEW HAMPSHIRE.

From 1921 to 1927 the author has made frequent collections of Cicadallidae from four distinct ecological associations in the vicinity of Durham, N. H. Those collections cover the whole year and represent a rather complete census of the leafhopper fauna of these associations. After some study, representative areas were selected in each of the associations and the work was concentrated on these. None of the areas are over 2.5 miles from tide water, or over 100 feet above sea level.

Gray's *Manual of Botany* is followed for the plant names. The author is indebted to the late Dr. Mabel M. Brown for assistance in plant determinations.

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*The studies of the leafhoppers of New Hampshire undertaken several years ago by Mr. Lowry contemplated extensive collections and habitat studies with faunistic comparisons of adjacent regions and with a view to use it as a doctorate dissertation in the Department of Entomology at the Ohio State University, of which Mr. Lowry was a graduate, receiving the Bachelor of Science degree in 1920 and Master of Science in 1921. He had made extensive collections and careful studies of certain ecologic regions with an exhaustive comparison of the New Hampshire fauna with that of adjacent territory, with the hope of early completion of the work which was interrupted by his untimely death, April 29, 1931.

In this work he had the advantage of correspondence and assistance from a number of specialists who will be found credited for certain help in the paper. After his death the notes were submitted to the writers for the purpose of assembling the available material for publication and there has been an effort to include so far as possible all of the records and discussion which had been carried to such a point as to be suitable for permanent record. For the most part the exact data as recorded by Mr. Lowry have been indicated with certain condensations to avoid duplication of records and locality citations and with indication by initials of the collectors he had given credit for specific records. The discussion of plant associations is presented in essentially the form in which the notes had been written up by Mr. Lowry and will be found to contain numerous valuable indications of ecological distribution for these insects. There can be no question that had Mr. Lowry lived to complete the study he would have prepared a most valuable contribution, especially with reference to ecological relations of the leafhoppers of the New England region as the notes and discussion of related faunae which had not been digested and written up in form for publication would certainly have added much to the material presented here.

The collecting was performed for the most part in the vicinity of Durham, N. H., and in the White Mountain region, consequently most of the records are from southern New Hampshire.

HERBERT OSBORN AND DWIGHT M. DELONG.

SALT MARSH.

This is a small salt marsh in an inlet of Great Bay, which is, at low tide, about half muck flat and half true marsh. A small tidal creek flows through the marsh, in which grow large masses of eel grass, *Zostera marina* L. and scattered sea lettuce, *Ulva*. *Fucus vesiculosus* grows in masses on a few rock masses projecting into the stream. Salt marsh grass, *Spartina glabra* Muhl. borders the stream and practically covers the muck flats with a pure stand. Most of the *Spartina* is partially submerged at high tide. Above the reach of ordinary tides, salt meadow grass, *Distichlis spicata* (L.), covers most of the area and mixed with it are clumps of black grass, *Juncus gerardi* Loisel. Scattered plants of the following species are also present: *Salicornia europaea* L., sea lavender, *Limonium carolinianum* (Walt.) Britton, seaside plantain, *Plantago decipiens* Barneoud, and toward the outer edge of the area, seaside goldenrod, *Solidago sempervirens* L. and *Spartina patens*, probably var. *caespitosa* (Eaton) Hitchc.

Surrounding the marsh are rough, bushy pastures and young, scrubby, mixed pine and hardwood stands.

The leafhoppers typical of this association are *Deltocephalus littoralis* Ball, rare on *Distichlis; Deltocephalus simplex* V. D. and *Hecalus lineatus* (Uhl.), both fairly common on *Spartina*, although the latter species is found inland on *Spartina*. Species collected in New Hampshire from this association only, but reported from other associations, are *Phlepsius ramosus* Baker and *Phlepsius fuscipennis* V. D., both rare on *Spartina patens*, and *Thamnotettix fitchii* V. D., rare on *Spartina glabra*. Other widely distributed species collected are *Draeculacephala mollipes* (Say) and *D. noveboracensis* (Fitch) often abundant; *Deltocephalus pascuellus* (Fall.), *Thamnotettix melanogaster* (Prov.), *Chlorotettix unicolor* Fitch and *Dikraneura fieberi* (Loew) fairly common; and *Gyponana octolineata* var. *striata* Burm., *Thamnotettix decipiens* Prov., *Cicadula sexnotata* (Fall.), *Platymetopius acutus* (Say) and *Euscelis cuneatus* S. & DeL. uncommon.

BOG.

This area is a small, but typical bog, surrounded on all sides by steep hills and known locally as "Spruce Hole." In the center is an open pond, advancing into which are leather leaf, *Chamaedaphne calyculata* and a sedge. Around the pond is a

zone containing the following: *Sphagnum*, leather leaf, cotton grass, *Eriophorum;* pitcher plant, *Sarracenia purpurea;* a sedge, round leaved sundew, *Drosera rotundifolia;* cranberry, *Vaccinium macrocarpon;* small plants of sheep laurel, *Kalmia angustifolia*, and pale laurel, *Kalmia palifolia*. Outside of this is a second zone in which the shrubs are large and have become dominant. The plants are the same, but the relative proportions have changed and there is in addition blueberry, *Vaccinium corymbosum;* small black spruce, *Picea mariana;* checkerberry, *Gaultheria procumbens*, and a fine, low sedge. Entirely surrounding the bog is a narrow third zone of close growing black spruce, 10 to 30 feet high, and growing among them creeping snowberry *Chiogenes hispidula*, goldthread *Coptis trifolia*, mosses and remnants of the preceding vegetation. Several cicadellids are characteristic of this association. *Cicadula pallida* Osb. common on sedge, *Euscelis striatulus* (Fall.) common on blueberry and *Euscelis humidus* (Osb.) not uncommon on blueberry, are confined to bogs in New Hampshire. *Platymetopius magdalensis* Prov. and its variety *cinnamoneus* Osb. common on blueberry, *Platymetopius fulvus* Osb. not common on blueberry, and *Erythroneura obliqua* var. ——— rare on sheep laurel, are regular inhabitants of bogs but have also been found on the same hosts in other associations. Other widespread species collected, of which *E. obliqua* is the commonest are: *Gyponana* var. *octolineata* var. *striata* Burm., *Scaphoidus productus* Osb., *Phlepsius collitus* Ball, *Thamnotettix decipiens* Prov., *Jassus olitorius* Say, *Balclutha punctata* (Thun.), *Dikraneura fieberi* (Loew), *Erythroneura obliqua* (Say) and its varieties *noevus* (Gill.) and *fumida* (Gill.) and *Erythroneura maculata* (Gill.). *Oncopsis sobrius* (Walk.) was taken rarely, but is probably a stray from surrounding birches.

WHITE PINE–HEMLOCK FOREST.

This lies in the University forest which consists of about 50 acres of old growth white pine and hemlock. The area studied is almost entirely made up of large trees of *Pinus strobus* and *Tsuga canadensis*, with an occasional *Betula lenta* or *Fagus grandifolia*. Where the stand is undisturbed there is little undergrowth, the commonest plant being *Mitchella repens*. In small openings caused by windfalls, there is a rich flora, of which the following, representing a little over half the species observed are the most important:

SMALL TREES AND SEEDLINGS.
Betula leuta.
Tsuga canadensis.
Pinus strobus.
Fagus grandifolia.
Acer rubrum.
Quercus alba.
Quercus rubra.
Tilia americana.
Fraxinus americana.
Acer saccharum.
Betula lutea.

SHRUBS.
Taxus canadensis.
Lonicera canadensis.
Corylus rostrata.
Rubus triflorus.
Rubus idaens aculeatissimus.
Rubus.
Diervilla lonicera.
Cornus alternifolia.
Viburnum acerifolium.
Viburnum dentatum.

HERBS.
Polypodium vulgara.
Phegopteris dryopteris.
Polystichum acrostichoides.
Aspidium spinulosum intermedium.
Lycopodium lucidulum.
Lycopodium clavatum.
Lycopodium obscurum.
Lycopodium complanatum.
Clintonia borealis.
Smilacina racemosa.
Oakesia sessilifolia.
Epipactis pubescens.
Hepatica triloba.
Maianthemum canadense.
Anemone quinquefolia.
Coptis trifolia.
Aralia nudicaulis.
Chimaphila umbellata.
Cornus canadensis.
Pyrola chlorantha.
Pyrola elliptica.
Monotropa uniflora.
Gaultheria procumbens.
Trientalis americana.
Mitchella borealis americana.
Epigaea repens.
Aster acuminatus.
Aster, spp.
Solidago, spp.

In addition there are scattered bunches of grasses and sedges and the drier spots often have *Cypripedium acaule.* In a single quite moist, open area is found *Sambucus racemosa, Rubus hispidus, Impatiens biflora, Viola incognita* and *Viola conspersa.*

This seems to be a temporary climax in this region. In the deeper, moist, richer soil a mixed stand occurs with a high percentage of hardwoods which is probably the true climax. The ground cover is dominated by herbs and shrubs of the northeast evergreen forest type. The common occurrence of many southern forms over this region is probably due to invasions following the settling and clearing of the country.

Leafhoppers are not particularly abundant in this association, the vegetation in the openings yielding most of them.

Thamnotettix belli (Uhl.) and its variety *brunneus* Osb. rare on shrubs and *Eupteryx vanduzei* Gill. not uncommon on wood fern, have been taken in New Hampshire in this association only. *Pagaronia tripunctata* Fitch, common on *Mitchella,* and *Thamnotettix morsei* Osb. rare on shrubs (oak?) are more common here than elsewhere in New Hampshire. All the remaining species taken are common and widespread, as numerous or more so, in other associations. *Oncopsis variabilis* (Fitch), *Oncopsis sobrius* (Walk.) and *Empoasca* sp. were fairly common on sweet birch. *Eupteryx flavoscuta* Gill. and

its varieties *juvenis* McA., *clavalis* McA. and *nigra* Osb. were common on wood fern, as were also nymphs and adults of *Graphocephala coccinea* (Forst.). The adults of the latter species were also common on other shrubs and herbs. *Platymetopius magdalensis* Prov. was rare on *Vaccinium pennsylvanicum*. *Cicadula slossoni* V. D. was common on *Impatiens*. The following species were taken on grasses and sedges: *Agallia novella* (Say) and *Balclutha punctata* (Thun.) fairly common, *Dikraneura fieberi*, rare, *Agallia 4-punctata* (Prov.) and *Cicadula sexnotata* (Fall.) not common, and *Chlorotettix balli* Osb. rare. General sweeping of herbs and shrubs yielded the following: *Scaphoideus productus* Osb., *Erythroneura maculata* Gill., *Erythroneura obliqua* (Say) with its varieties *noevus* (Gill.), *fumida* (Gill.) and *parma* McA., common; *Scaphoideus auronitens* Prov., *Scaphoideus scalaris* V. D., *Scaphoideus immistus* Say, *Gyponana octolineata striata* Burm. and *Thamnotettix kenicotti* (Uhl.) fairly common; *Platymetopius acutus* (Say), *Jassus olitorius* Say, *Empoasca birdii* Goding, *Mesamia vitellina* (Fitch) and *Erythroneura comes* var. *vitifex* Fitch and variety *rubra* (Gill.) rather rare.

DRY, SANDY UPLANDS.

This area is a level, well drained glacial outwash with very sandy, dry soil. The whole area is covered with clumps of *Andropogon scoparius* and irregularly scattered throughout are pitch pines, *Pinus rigida*, from one to thirty feet high, occurring in groups or singly. There are also a few small, scattered gray birch, *Betula populifolia* and white pine, *Pinus strobus*. Scattered through the dominant *Andropogon* are the following: *Aristida gracilis*, *Rubus villosus*, *Potentilla pumila*, *Aster linariifolius*, *Aster* sp., *Solidago* two spp., a sedge, *Potentilla argentea*, *Lysimachia quadrifolia*, *Rumex acetosella*, *Hypericum perforatum*, *Antennaria canadensis*, *Fragaria virginiana*, reindeer moss (*Cladonia*).

Complete clearing, and cultivation, followed by periodical fires, probably account for this type of association. This is a xerophytic association of high temperature and having both prairie and heath aspects. A number of southern and prairie leafhoppers are restricted to this association in New Hampshire or are found in greatest numbers here.

At the edges of the area the dewberry increases, *Myrica asplenifolia* is common, and the following appear: *Pteris aquilina*, *Rhus copallina* and *Vaccinium vacillans*.

The following have been collected from the pitch pine: *Paracoelidea tuberculata* Baker, abundant, *Phlepsius graniticus* O. & L. and *Platymetopius angustatus* Osb., common, *Thamnotettix* n. sp. (near *perspicillatus*), rare, and *Gyponana octolineata tenella* Spbg., rare. The foregoing have been taken on this host only. *Empoasca coccinea* (Fitch) is common, but occurs on other pines elsewhere. *Phlepsius carolinus* Lathrop and *Phlepsius tullahomi* DeL. are found, but are much more common in the herb stratum. Widespread species not commonly taken are *Mesamia vitellina* (Fitch), *Scaphoideus immistus* (Say) and *Thamnotettix kennicotti* (Uhl.).

The following species have been taken on the *Andropogon* and associated plants: *Deltocephalus sandersi* Osb., abundant on *Andropogon*, *Phlepsius tullahomi* DeL. is common, *Parabolocratus flavidus* Sign. is fairly common, *Prairiana cinerea kansana* Ball, *Aligia modesta* (O. & B.) and *Deltocephalus caperatus* Ball are rare. All the above have been taken in New Hampshire in this association only. The following are commonest in this association in New Hampshire: *Deltocephalus unicoloratus* G. & B., abundant, *Phlepsius carolinus* Lat. and *Acinopterus acuminatus* V. D. fairly common, and *Driotura gammaroides* (V. D.) rare. The following are of more or less common occurrence: *Deltocephalus melsheimerii* (Fitch), *Deltocephalus configuratus* Uhl., *Deltocephalus misellus* Ball, *Deltocephalus compactus* O. & B., *Deltocephalus sayi* (Fitch) and *Aconura acuticauda* (Baker). Species rarely taken are *Deltocephalus obtectus* O. & B., *Xestocephalus pulicarius* V. D., *Platymetopius acutus* (Say), *Eutettix cinctus* O. & B., *Chlorotettix unicolor* (Fitch) and *Erythroneura maculata* Gill.

ABBREVIATIONS.

The names of collectors credited in the following records are indicated by initials as follows:

E. D. B.—E. D. Ball.
J. C. B.—J. C. Bridwell (N. H. Agr. Exp. Sta. Coll.).
R. A. C.—R. A. Cushman (N. H. Agr. Exp. Sta. Coll., Bost. Soc. Nat. Hist.).
D. M. D.—D. M. DeLong.
W. F. F.—W. F. Fiske (N. H. Agr. Exp. Sta. Coll.).
C. W. J.—C. W. Johnson (Bost. Soc. Nat. Hist.).
J. C. K.—J. C. Kendall (N. H. Agr. Exp. Sta. Coll.).
W. L. M.—W. L. McAtee.
A. T. S.—Mrs. Annie Trumbull Slosson.
J. S.—J. Smith (N. H. Agr. Exp. Sta. Coll.).
M. J. S.—M. J. Smith (Woodman Institute Coll.).
L. W. S.—L. W. Swett?

RECORDS OF COLLECTIONS

Agallia novella (Say). Dover, July 19, 1922; Durham, June 5, 29, July 7, 8, 14, August 27, 1922, June 23, July 18, August 11, 1923, May 14, 1924, May 16, June 12, 1925; Franconia, August 2, 1930; Hill, July 23, 1923; Mt. Clinton, July 30, 1900 (W. F. F.); Mt. Washington, reported for alpine region at or above 5,500 ft. (A. T. S., 1895), July 4, 1914 (C. W. J.); White Mountains, July 26, 1900 (W. F. F.); Wonalancet, July 17, 1930.

Agallia quadri-punctata (Provancher). Reported for State (O. & B., 1898); Durham, May 26, 1899 (W. F. F.), June 5, 6, July 8, 1922; May 31, June 5, 23, July 2, 1923, June 12, 1925; Hanover, June 8, July 18, 1892 (C. M. W.); Jaffrey, June 15, 1917 (C. W. J.); Mt. Clinton (near summit), July 30, 1900 (W. F. F.); Raymond, July 13, 1930.

Agallia sanguinolenta (Provancher). Dixville, September 9, 1930; Durham, September 8, 13, 22, 30, 1921, March 15, June 5, July 7, 11, 21, August 29, October 2, 5, 1922, May 7, July 18, 27, September 11, 1923; Hill, July 23, 1923; Mt. Washington (summit), September 3, 1925; North Hampton, September 13, 1922; Portsmouth, September 3, 1922; Twin Mountains, July 28, 1900. Common in meadows.

Idiocerus amabilis Ball. Durham, August 19, 1927, from willow, (det. E. D. B.).

Idiocerus pallidus Fitch. Durham, July 9, 1898 (W. F. F.), August 18, 1899 (R. A. C.), September 13, 1921, August 29, September 7, 14, 21, 1922, July 5, 27, 1923; Franconia, August 2, 1930; Hanover, July 28, 1892 (C. M. W.); Hill, July 23, 1923; Mt. Washington, reported for alpine region (A. T. S., 1895); Twin Mountain, July 28, 1900 (W. F. F.); Webster, July 17, 1900 (W. F. F.); Wonalancet, July 17, 1930. Common on willow.

Idiocerus suturalis Fitch. Durham, July 6, 9, 1925; Franconia, August 2, 1930; Lee, September 9, 1928, August 7, 1930; Mt. Washington, reported for alpine region (A. T. S., 1895); reported (O. & B., 1898); Newmarket, July 23, 1930; Rochester, July 10, 1930; Rockingham, August 21, July 7, 1928. On small-toothed aspen.

Idiocerus suturalis var. *lunaris* Ball. Durham, July 6, 9, 1925; Franconia, August 2, 1930; Lee, July 7, 1928; Rochester, July 10, 1930; Rockingham, August 21, July 7, 1928; Twin Mountain, July 28, 1900 (W. F. F.); Webster, July 17, 1900 (W. F. F.). On small-toothed aspen.

Idiocerus suturalis var. *vagus* Ball. Mt. Washington, reported for alpine region (A. T. S., 1908).

Idiocerus duzeei Provancher. Reported for State (O. & B., 1898); Durham, July 23, 1921; Franconia (A. T. S.), reported (O. & B., 1898).

Idiocerus alternatus Fitch. Durham, July 20, 1898 (W. F. F.), April 19, May 16, 1900, July 9, 1923; Franconia (A. T. S.), reported (O. & B., 1898). On willow.

Idiocerus productus Gillette and Baker. Mt. Washington, reported for alpine region (A. T. S., 1906).

Idiocerus formosus Ball. Mt. Washington, reported for alpine region (A. T. S., 1906).

Idiocerus lachrymalis Fitch. Occurs wherever *Populus tremuloides* is present.

Idiocerus provancheri Van Duzee. Isles of Shoals, August 2, 1928 *Pyrus arbutifolia*); Pinnham Notch (Glen House), July 23, 1915 (C. W. J.), July 21, 1922 (J. A. C.); Mt. Monadnock, September 6, 1906; Mt. Washington, reported for alpine region (A. T. S., 1896), (A. T. S.), reported (O. & B., 1898).

Idiocerus fitchi Van Duzee. Durham, July 9, 1899, in trap lantern (W. F. F.); July 20, 22, 1921, July 11, 1922; Nashua, August 11, 1924; Wilton, August 11, 1927. On apple.

Macropsis virescens (Gmelin). Durham, July 2, 5, 9, 27, 1923; Rye, July 25, 1928. Common on willow.

Macropsis virescens var. *graminea* (Fabricius). Durham, July 2, 5, 9, 27, 1923; Rye, July 25, 1928. Common on willow.

Macropsis viridis (Fitch). Durham, July 11, 1898 (W. F. F.), July 11, 1922, June 23, July 5, 9, 27, August 11, 1923; Farmington, July 6, 1923; Franconia, August 2, 1930, on willow.

Macropsis suturalis (Osborn and Ball). Durham, July 5, 27, 1923; Rye, July 25, 1928. On willow.

Macropsis basalis (Van Duzee). Durham, July 8, 1922, July 9, 1923, July 19, 1925; Exeter, July 9, 1925; Lee, August 7, 1930; Wonolancet, June 20, 1930. On small-toothed aspen.

Macropsis basalis var. *fumipennis* Gillette and Baker. Durham, July 19, 1925, on small-toothed aspen.

Macropsis canadensis (Van Duzee). Durham, July 5, 27, 1923. On willow.

Macropsis bifasciata (Van Duzee). Durham, July 9, 27, 1923, July 19, 1925; Exeter, July 9, 1925; Farmington, July 6, 1923; Newmarket, July 23, 1930. On large- and small-toothed aspen.

Macropsis trimaculata (Fitch). Durham, July 26, 1924, common on a few plum trees in Uni. plum orchard; cast nymphal skins found on underside of leaves; no apparent injury to infested trees.

Macropsis sordida (Van Duzee)? Durham, July 6, 1925. On quaking aspen. (Do not fit description, are probably what has been called *sordida* in the East; perhaps a new species.)

Oncopsis variabilis (Fitch). Common on birch. Taken at Alton, Bretton Woods, Crawfords, Durham, Epping, Fabyans, Hill, Mt. Washington, Pinkham Notch.

Oncopsis sobrius (Walker). Durham, July 10, 11, 1898 (W. F. F.), June 5, 1922, July 7, June 23, July 1, 18, 27, 1923; Epping, June 27, 1898 (W. F. F.); Farmington, July 6, 1923; Hanover, July 21, 1892 (C. M. W.); Hill, July 23, 1923; Mt. Washington, (A. T. S., 1894), alpine region at or above 5,500 feet; Ossipee, July 11, 1929; Rye, August 9, 1929. On birch.

Oncopsis cognatus (Van Duzee). Mt. Washington, reported for alpine region (A. T. S., 1902).

Oncopsis fitchi Van Duzee. Alton, July 4, 1927; Mt. Clinton (summit), July 30, 1900 (W. F. F.); (near summit), July 26, 30, 1900 (W. F. F.); Mt. Washington, reported for alpine region (A. T. S., 1896), July 24, 1900 (at base), (W. F. F.); White Mountain (alpine summits of Presidential Range), July 26, 28, 31, 1900 (W. F. F.). On birch.

Oncopsis pruni (Provancher). Durham, July 17, 1898 (W. F. F.), July 7, 8, 18, 21, 1922, July 18, 27, 1923, July 6, 1925; Epping, June 27, 1898 (W. F. F.); Hill, July 23, 1923; Mount Washington, reported (A. T. S., 1894) for alpine region; White Mountains, "subalpine" (Scudder), reported by E. P. Van D., 1890. Common on birch.

Oncopsis minor (Fitch). Reported for State in Van Duzee's Cat.; Jackson, September 18, 1927, on yellow birch.

Oncopsis nigrinasi (Fitch). Durham, July 15, 20, 1898 (W. F. F.), June 24, 1899 (J. C. K.), June 29, July 2, 7, 14, 1922 (R. A. C.), July 9, 1923, July 8, 1928. Common on hop hornbeam.

Oncopsis fagi (Fitch)? Durham, July 20, 1898 (W. F. F.), July 8, 1922. From hornbeam and river beech. (The above two specimens may not be the *fagi* of Fitch, but they are surely a distinct species.)

Oncometopia lateralis (Fabricius). Durham, August 18, 1899 (R. A. C.), September 18, 1921, June 14, 1924, September 4, 1927; Littleton, September 9, 1895 (C. M. W.); Mount Washington, reported (A. T. S., 1894); Nottingham, October 9, 1898 (W. F. F.), September 4, 1927; Pinnham Notch (Glen House), September 22, 1907 (C. W. J.); Twin Mountain, July 28, 1900 (W. F. F.).

Cicadella gothica (Signoret). Common at all localities collected, especially in roadside vegetation.

Cicadella gothica var. *atra* Barber. Durham, September 16, 1921, on wild rose, October 2, 1922.

Kolla bifida (Say). Durham, September 4, 1897 (W. F. F.), August 30, September 1, 8, 14, 23, 26, October 2, 1922, August 1, 11, 1923; Hanover, August 2, 1892, August 18, 1892 (C. M. W.); reported for State (Ball, 1901); Nottingham, September 4, 1927; Portsmouth, September 3, 1922; Webster, August 4, 1898 (W. F. F.); Wonalancet, September 27, 1930. In wet meadows, pastures, grass in low woods and along roadside.

Helochara communis Fitch. Durham, May 26, 1899 (W. F. F.), March 15, sifted from leaves, March 16, 1902 (R. A. C.), September 22, 1921; May 11, September 1, 7, October 2, 5, 1922, May 7, July 27, 1923; Dover, May 15, 1922 (flew into automobile); Littleton, September 9, 1895 (C. M. W.); Mount Washington, reported from alpine region (A. T. S., 1894); North Hampton, September 13, 1922; Nottingham, October 9, 1898 (W. F. F.); Portsmouth, September 3, 1922. Common on swamp grasses and sedges.

Graphocephala coccinea (Forster). Common at all localities collected, especially in undergrowth of woods or along roadsides.

Graphocephala coccinea var. *teliformis* (Walker). Crawfords, July 26, 1900 (W. F. F.), near summit of Mt. Clinton; Durham, July 23, 1921.

Draeculacephala angulifera (Walker). Jefferson, September 18, 1927, in wet woods.

Draeculacephala manitobiana Ball. Durham, September 14, 1921, July 25, 1925; Jefferson, September 18, 1927, in wet meadow.

Draeculacephala mollipes (Say). Common everywhere on grasses and sedges of moist meadows and woods.

Draeculacephala noveboracensis (Fitch). Durham, July 20, 1922, September 1, 21, 1922, July 28, 1924; Hampton, July 16, 1930; Hanover, July 21, 1892; Littleton, September 9, 1895 (C. M. W.); Lee, August 7, 1930; Portsmouth, September 3, 1922. Common on swamp grass.

Pagaronia (*Kolla*) *tripunctata* (Fitch). Durham, September 4, 1897 (W. F. F.), August 30, September 7, 23, October 14, 1922, August 11, 1923; reported for State (E. D. B., 1901). On *Mitchella repens* and *Gaultheria procumbens.*

Evacanthus acuminatus (Fabricius). Fabyans, July 24, 1900 (W. F. F.); Mt. Washington, reported for alpine region (A. T. S., 1902), July 24, 1915 (W. W. J.); Pinkham Notch, Glen House, July 18, 20, 1915 (C. W. J.); White Mountains, July 31, 1900 (W. F. F.); Wonalancet, July 1, 17, 1930.

Penthimia americana Fitch. Durham, May 20, 1898, May 26, 1899 (W. F. F.); Farmington, July 6, 1923; Jaffrey, June 8, 1920 (C. W. J.). on gray birch.

Gyponana octolineata var. *octolineata* Say. Durham, September 14, 1921, August 29, September 7, 1922; Newmarket, November 1, 1897 (J. S.); Nottingham, October 9, 1898 (W. F. F.).

Gyponana octolineata var. *cana* Burmeister. Durham, September 28, 1897, July 7, 1899, trap lantern (W. F. F.), Aug. 9, 1899 (R. A. C.), September 14, 15, 1921; Jackson, Pinnham Notch, September 18, 1927; Mt. Clinton, July 30, 1900 (W. F. F.); Wonalancet, July 17, 1930.

Gyponana octolineata var. *striata* Burmeister. Common in all places where collecting was done, especially in roadside vegetation.

Gyponana octolineata var. *tenella* Spangberg. Durham, August 11, 1923, from pitch pine; Pelham, August 31, 1905 (J. C. B.).

Gyponana rugosa Spangberg. Nottingham, September 4, 1927, from white oak.

Gypona unicolor Stal. Dover, September 16, 1924 (M. J. S.); Durham, August 15, 1899 (R. A. C.), September 8, 1921, September 11, October 3, 1922; Portsmouth, September 3, 1922. From coarse grass in swampy areas.

Prairiana cinerea var. *kansana* Ball. Durham, July 6, 1925 (Det. E. D. B.). From *Andropogon* in sandy area among scattered pitch pines.

Ponana scarlatina var. *scarlatina* Fitch. Durham, June 6, 28, July 9, 12, 1899, from trap lantern (W. F. F.), September 4, 1923, at light in room.

Xerophloea major Baker. Lee, June 28, 1928, from coarse grass on lake shore.

Stroggylocephalus agrestis (Fallen). Mt. Washington, reported from alpine region (A. T. S., 1906).

Acucephalus nervosus (Schrank). Durham, July 10–September 23, 1922, June 23, July 1, 18, August 11, 1923; Franconia, August 2, 1930; Hill, July 23, 1923; Isles of Shoals, July 15, 1928, July 23–28, 1929; Lee, September 9, 1928, August 7, 1930; Portsmouth, September 3, 1922; Wonalancet, September 27, 1930. Common in grass in meadows.

Acucephalus albifrons (Linnaeus). Dover, July 19, 1922; Durham, August 6, 1900 (W. F. F.), July 21, September 1, 11, October 2, 1922, July 27, August 11, 1923, July 16, 1929, July 12, 1930; Hampton, July 16, 1930; Isles of Shoals, July 27, 1929; Mt. Washington, reported for alpine region (A. T. S., 1906); Rye, July 25, 1928; Waterville, October 2, 1898 (W. F. F.). Common in meadows.

Xestocephalus pulicarius Van Duzee. Durham, August 29, 30, September 8, 14, 1922; Newmarket, August 31, 1922; Nottingham, September 4, 1927; Portsmouth, September 3, 1922. Common in swampy meadows and grass along roadside.

Xestocephalus superbus (Provancher). Concord, August 12, 1929; Durham, August 29, September 21, October 2, 1922; Newmarket, August 31, 1922; Nottingham, September 4, 1927; Wonalancet, September 27, 1930.

Hecalus lineatus (Uhler). Durham, September 14, 1921, September 1, 1922, September 7, 1927; Hampton, July 16, 1930, from tall coarse grass at edge of salt marsh.

Parabolocratus viridis (Uhler). Reported for State in Van Duzee's Cat. Hem.

Parabolocratus major Osborn. Hill, June 23, 27, 1923, from neadow.

Parabolocratus flavidus Signoret. Durham, September 13, 15, 1924 (Det. E. D. B.), August 18, 1927.

Aligia modesta (Osborn and Ball). Durham, September 6, 1924 (Det. E. D. B.). Pitch pine barren.

Mesamia vitellina (Fitch). Durham, September 4, 1897 (W. F. F.), August 1, 1898 (W. F. F.), July 11, 14, September 8, October 2, 1922, July 1, 1923; Hill, July 23, 1923; Isles of Shoals, July 26, 1929; Lee, August 12, 1930; reported for State (Slosson—coll.) (E. D. B., 1907); Nottingham, September 4, 1927; Raymond, July 13, 1930. From shrubs.

Scaphoideus auronitens Provancher. Durham, July 24, September 13, 15, 16, 22, 30, 1921, August 27, 30, September 8, 25, October 14, 1922. A common species on undergrowth in open woods.

Scaphoideus jucundus Uhler. Durham, September 21, 1922, August 28, 1924; Ossipee, September 17, 1927 (Det. E. D. B.). Swept from bushes along roadside.

Scaphoideus scalaris Van Duzee. Durham, August 27, 29, 30, September 14, 23, October 2, 14, 1922; Newmarket, August 31, 1922; Mt. Washington, recorded for alpine region (A. T. S., 1902).

Scaphoideus lobatus Van Duzee. Durham, September 15, 1921, October 2, 1922; Portsmouth, September 3, 1922; Mt. Washington, reported for alpine region (A. T. S., 1902).

Scaphoideus ochraceus Osborn. Recorded for State in V. D. Cat. Hem.; Durham, record (H. O., 1911).

Scaphoideus productus Osborn. Lee, August 12, 1930; Raymond, July 14, 1930; Rochester, July 10, 1930; Wonalancet, July 17, 1930. In heath-shrub association.

Scaphoideus carinatus Osborn. Hanover, one female used in original description (H. O., 1900); Center Harbor, September 10, 1914 (C. W. J.); Jackson, September 18, 1927. From shrubs at edge of woods or along road.

Scaphoideus intricatus Uhler. Franconia (A. T. S.), reported (H. O., 1911).

Scaphoideus immistus (Say). Dublin, August 20; Mt. Washington, reported for alpine region (A. T. S., 1902); Pinkham Notch, Glen House, July 15, 1915 (C. W. J.); Wonalancet, July 17, 1930. Common.

Scaphoideus immistus var. *minor* Osborn. Durham, August 29, 1922, from white pine.

Scaphoideus melanotus Osborn. Durham, July 11, 1922.

Platymetopius acutus (Say). An abundant species in the State on grass in meadows, pastures, swamps, on sedges, blueberry, ferns, willow, dogwood, etc.

Platymetopius cuprescens Osborn. Twin Mountain, July 28, 1900 (W. F. F.).

Platymetopius angustatus Osborn. Durham, September 6, 15, 1924, August 18, 1928; Madbury, September 5, 1927; Nottingham, September 4, 1927; Lee, August 18, 1927; Ossipee, September 17, 1927. Common on pitch and red pine.

Platymetopius fulvus Osborn. Durham, September 16, 1921, August 30, September 23, 1922, September 19, 1924. On blueberry.

Platymetopius frontalis Van Duzee. Webster, August 4, 1898 (W. F. F.).

Platymetopius magdalensis Provancher. Durham, July 14, August 29, September 7, 8, 21, 23, 1922, July 1, 18, August 11, 1923; Hill, July 23, 1923; Lee, August 12, 1930; Raymond, July 13, 1930; Rochester, July 10, 1930; Wonalancet, July 17, 1930. Common on blueberry.

Platymetopius magdalensis var. *cinnamoneus* Osborn. Concord, August 12, 1929; Durham, August 29, 30, September 8, 23, 1922, July 1, 1923; Rochester, July 10, 1930; Wonalancet, July 17, 1930. Common on blueberry.

Flexamia sandersi (Osborn). Durham, August 29, September 8, 21, October 2, 1922, July 1, 1923, August 28, September 6, 1924; Farmington, July 6, 1923, October 2, 1924; Lee, August 7, 1930; Newmarket, August 31, 1922; Rochester, July 10, 1930. Common on Andropogon.

Flexamia delector (Sanders and DeLong). Durham, July 14, 1922, July 18, 1923, from short, fine grass in shady woods, August 11, 1923. (Weed—coll.) Reported by D. M. DeLong, 1926. The species referred to by Osborn and Ball as *D. bilineatus* G. & B., "collected in N. H. by Professor Weed" (1897) probably refers to this species; as does also the specimen called *D. productus* Walk. by Osborn (1915), collected at Hanover (C. M. W.).

Latulus configuratus (Uhler). Durham, June 1, 2, July 5, 18, 1923, May 22, 1925; Farmington, July 6, 1923; Franconia, August 2, 1930; Hill, July 23, 1923; Lee, June 28, 1928; Mt. Washington, reported from alpine region by A. T. S., 1894, July 4, 1914 (C. W. J.); Webster, July 18, 1900; White Mountains, July 30, 1900 (W. F. F.); Wonalancet, June 20, 1930. Common in dry areas on Andropogon.

Latulus sayi (Fitch). A common species of meadows and pastures.

Latulus misellus (Ball). Found in most places where collecting was done. Common in meadows and sterile pastures.

Polyamia obtecta (Osborn and Ball). Durham, September 21, 23, 1922, July 18, September 11, 1923; Rumney, September 28, 1927. From dry upland pasture and from dry meadow.

Polyamia compacta (Osborn and Ball). Durham, July 17, September 11, 23, 1922, July 1, 18, 1923, September 15, 1924; Hill, July 23, 1923. Taken in dry pastures.

Polyamia apicata (Osborn). Durham, September 8, 1921, July 11, 14, 17, September 8, 11, 1922, July 1, 5, 18, 1923; Webster, July 18, 1900 (W. F. F.). Taken in dry pastures.

Polyamia caperata (Ball).—(*vinnulus* Crumb). Durham, September 15, 1924, on Andropogon in sandy pitch pine area.

Polyamia inimica (Say). Common throughout the state in meadows and pastures.

Laevicephalus melsheimerii (Fitch). Durham, July 7, 20, August 30, September 7, 8, 25, 28, 1922, July 1, 5, 18, September 11, 1923; Farmington, July 6, 1923; Hill, July 23, 1923; Lee, June 28, 1928; Mt. Washington, reported for alpine region (A. T. S., 1898); Wonolanset, June 20, 1930. A common species in dry pastures.

Laevicephalus unicoloratus Gillette and Baker. (*oculatus* O. & B., *nominatus* S. & DeL.). Durham, September 1, 21, 1922, July 2, 5, 1923, June 13, 1930; Farmington, July 6, 1923, October 2, 1927; New Hampshire, recorded by D. M. D., 1926; Newmarket, August 31, 1922; Webster, August 4, 1898 (W. F. F.). From dry pastures.

Laevicephalus sylvestris (Osborn and Ball). Durham, September 21, 1922, August 11, 1923; Fabyans, July 24, 1900 (W. F. F.); Rochester, July 10, 1930; White Mountains, July 30, 1900, from summit Mt. Clinton (W. F. F.).

Laevicephalus acus (Sanders and DeLong). Concord, August 12, 1929; Durham, August 29, September 8, 1922, July 1, August 11, 1923; Franconia, August 2, 1930; Hill, July 23, 1923; Isles of Shoals, July 23–28, 1927; Nottingham, September 4, 1927. Common in dry upland pastures.

Laevicephalus pascuellus (Fallen). Durham, September 8–October 3, 1921, July 7–October 28, 1922, June 23, 1923, September 1, 1924, August 15, 1926; Fabyans, September 2, 1928; Mt. Washington, reported for alpine region (A. T. S., 1906); North Hampton, September 13, 1922; Portsmouth, September 3, 1922; Rye, June 30, 1928; Wonolanset, June 20, 1930. Common in meadows, pastures, and swampy areas.

Laevicephalus abdominalis (Fabricius). Reported for State (D. M. D., 1926); Twin Mountain, July 28, 1900 (W. F. F.).

Laevicephalus debilis (Uhler). Fabyans, July 24, 1900 (W. F. F.); reported from State (D. M. D., 1926); Twin Mountain, July 28, 1900 (W. F. F.).

Laevicephalus littoralis (Ball). Durham, September 7, 1927. In salt marsh.

Laevicephalus striatus (Linnaeus), (*affinis* G. & B.). Durham, June 5, 1922, September 23, 1922; Isles of Shoals, July 23–28, 1929; White Mountains, July 26, 30, 31, 1900, from summit of Mt. Clinton (W. F. F.).

Amplicephalus simplex (Van Duzee). Durham, September 1, 1924. From *Spartina*, salt marsh.

Deltocephalus flavicostus (Stal). Durham, July 18, 1923, swept from dry hilltop pasture, closely grazed.

Deltocephalus pulicarius (Fallen). Mt. Washington (base), September 7, 1920 (L. W. S.).

Deltocephalus balli Van Duzee, September 23, 1922.

Aconura acuticauda (Baker). Durham, July 17, 20, September 8, 1922, May 17, July 1, 18, 1923, September 6, 15, 1924; Farmington, July 6, 1923; Hill, July 23, 1923; Webster, July 18, 1900 (W. F. F.); Wonolanset, June 20, 1930. Common in dry sandy pastures.

Driotura gammaroides (Van Duzee). Durham, September 1, 1922, July 18, 1923, May 22, July 6, 1925; Lee, August 7, 1930. Common in pasture.

Drylix striolus (Fallen). North Hampton, July 16, 1930. Common in salt marsh among grasses and sedges.

Euscelis extrusus (Van Duzee). Reported for State (O. & B., 1902); Hanover, July 8, 1908 (C. W. J.); Mt. Washington (near base), July 24, 1900 (W. F. F.).

Euscelis alpinus (Ball). Recorded for State in Van Duzee's Cat. Hem.

Euscelis obsoletus (Kirschbaum)—Ball says: *deceptus* S. & DeL. = *relativus* G. & B. = *obsoletus* Kirschbaum. Mt. Washington (base), September 7, 1920 (L. W. S.).

Ophiola uhleri (Ball). Durham, August 1, 1898, swept from goldenrod (W. F. F.), June 28, 1900, from trap lantern (W. F. F.), July 18, 1923; Hanover, July 28, 1892 (C. M. W.), July 8, 1908 (C. W. J.); reported for State (O. & B., 1902).

Ophiola anthracina (Van D.). Hanover, July 8, 1908 (C. W. J.).

Ophiola cuneata (Sanders and DeLong). Durham, September 8, 22, 1921, July 7–October 2, 1922, July 1, 9, 1923; Hill, July 23, 1923; North Hampton, September 13, 1922; Portsmouth, September 3, 1922; Lee, August 7, 1930. Common in wet meadows.

Ophiola arctostaphyli (Ball). Mt. Washington, reported for alpine region (A. T. S., 1902), (O. & B., 1902), September 3, 1925, 6,200 ft. (Det. E. D. B.).

Ophiola humida (Osborn). Durham, September 23, 1922, August 28, September 4, 19, 1924; Jackson, September 18, 1927, (Det. E. D. B.). From bog shrubs.

Ophiola striatula (Fallen). Durham, September 23, 1922, July 1, 1923, August 28, September 4, 19, 1924; Isles of Shoals, July 23–28, 1929. Common in boggy areas.

Ophiola comptoniana Ball. Durham, September 10, 1921, September 21, 23, 1922, July 18, September 11, 1923; Lee, August 12, 1930; Madbury, September 5, 1927; Ossipee, September 17, 1927; Rochester, July 10, 1930; Webster, August 4, 1898 (W. F. F.); Wonalancet, July 17, 1930. Common in heath-shrub association.

Ophiola osborni Ball. Durham, July 17, 1922, July 5, 1923, July 21, 1930; Jackson, September 18, 1927; Lee, August 7, 1930; Wonalancet, July 17, 1930. Common in dry shrubby area.

Ophiola angustata (Osborn). Mt. Washington, September 3, 1925, 6,200 ft. (May not this also be *plutonia?*)

Ophiola cornicula (Marshall). Mt. Washington, September 3, 1925, 6,200 ft.

Commellus comma (Van Duzee). Mt. Washington, reported for alpine region (A. T. S., 1902); reported for State (O. & B., 1902); Webster, July 18, 1900, in dry stubble field (W. F. F.).

Amblysellus curtisii (Fitch). Reported for State (O. & B., 1902); Durham, September 1, 1897 (W. F. F.), October 15, 1898 (W. F. F.), June 27, 1900 (R. A. C.), September 8, 26, 1921, July 7–October 3, 1922, June 23, July 5, 1923; Hanover, August 18, 1892 (C. M. W.); Haverhill, October 7, 1927; Waterville, October 2, 1898 (W. F. F.); Webster, August 1, 1898 (W. F. F.); White Mountains, July 31, 1900 (W. F. F.).

Eutettix luridus (Van Duzee). Durham, September 14, 21, 1922 (Det. E. D. B.). From oak.

Eutettix marmoratus (Van Duzee). Durham, September 15, 1921, August 30, 1922 (Det. E. D. B.); Ossipee, September 17, 1927 (Det. E. D. B.).

Eutettix southwicki Van Duzee. Ossipee, September 17, 1927, common on scrub oak on dry sandy hillside (Det. E. D. B.).

Eutettix johnsoni (Van Duzee). Alton, August 19, 1928; Durham, September 16, 1921, October 5, 1922, August 18, 1928; reported for state (Weed—coll.) (E. D. B., 1907); Nottingham, September 4, 1927; Webster, July 21, 1900 (W. F. F.); Wonalancet, July 17, 1930. Taken in damp forest or woods.

Eutettix seminudus (Say). Durham, July 11, 1922.

Eutettix cinctus Osborn and Ball. Durham, August 30, September 21, 1922, September 15, 1924; Newmarket, August 31, 1922. From scrub white oak at edge of woods.

Phlepsius graniticus Osborn and Lathrop. Durham, September 21, 1922, September 6, 15, 1924, August 18, 1927; Lee, September. From pitch and red pine.

Phlepsius fuscipennis Van Duzee. Durham, July 21, 1897, from salt marsh (W. F. F.).

Phlepsius collitus Ball. Durham, July 11, 1898 (W. F. F.), September 8, 1921, July 7, August 30, September 1, October 5; Hill, July 23, 1923. From willow and blueberry.

Phlepsius irroratus (Say). Common on grass in meadows, pastures; taken on willow and *cornus*.

Phlepsius apertus Van Duzee. Jefferson, September 18, 1927. From roadside grass.

Phlepsius carolinus Lathrop. Durham, August 29, September 21, 1922, September 13, 15, 1924, August 18, 1928; Farmington, October 2, 1927. From blueberry, pitch pine, Andropogon, etc.

Phlepsius fulvidorsum (Fitch). Durham, August 18, 1899 (R. A. C.), July 17–October 3, 1922, July 1, 1928; Franconia, August 2, 1930; Hill, July 23, 1923; Lee, September 9, 1928, August 7, 1930; Littleton, September 9, 1895 (C. M. W.); Nottingham, September 4, 1927; Portsmouth, September 3, 1922; Rochester, July 10, 1930; Webster, August 4, 1898 (W. F. F.).

Phlepsius tullahomi DeLong—*slossoni* var. *fastuosus* Ball (1927). Durham, September 13, 1921, September 6, 13, 15, 1924; Farmington, July 6, 1923; Webster, July 21, 1900 (W. F. F.). From birch, Andropogon, pitch pine barren, etc.

Phlepsius franconianus Ball—*P. strobi* (1927). Described (E. D. B., 1903) from male from Franconia collected (A. T. S.).

Phlepsius strobi (Fitch). Durham, July 3, 1924. From white pine (Det. E. D. B.).

Phlepsius nebulosus Van D. Durham, (H. O., 1905).

Phlepsius solidaginis (Walker). Durham, September 22, 1921, August 29, September 7, 11, 1922. From swamp grass.

Phlepsius ramosus Baker. Durham, July 7, 1899, in trap lantern (W. F. F.), September 1, 1924, September 7, 1927 (Det. E. D. B.). From salt marsh.

Phlepsius bifidus Sanders and DeLong. Portsmouth, September 3, 1922, from wet, bushy pasture.

Phlepsius decorus Osborn and Ball. Newmarket, August 31, 1922, from grass in open woods.

Acinopterus acuminatus Van Duzee. Durham, August 29, 1922, September 6, 13, 15, 1924, August 18, 1927, August 18, 1928; Nottingham, September 4, 1925. From pitch pine barren.

Thamnotettix kennicotti (Uhler). Durham, July 11, 1898 (W. F. F.), July 23, 1921, July 14–October 14, 1922, July 18, 1923; Mt. Washington, reported (A. T. S., 1895) alpine region; Lee, August 7, 1930; Rochester, July 10, 1930. From birch, Cornus, pitch pine and in low bushy pastures and meadows.

Thamnotettix subcupraeus (Provancher). Reported for State in Van Duzee's Cat. Hem.

Thamnotettix morsei Osborn. Durham, September 16, 1921, August 30, September 7, 23, 25, 1922. Swept from shrubs.

Thamnotettix clitellarius (Say). Durham, September 4, 1897 (W. F. F.), July 6–7, 1899 (R. A. C.), June 22, 28, 1900, in trap lantern (W. F. F.), June 27, 29, July 2, 1900 (R. A. C.), September 13–14, 1921, October 5, 1922, July 5, 9, 1923; June 27, 1924; Fabyans, September 2, 1928; Dover, July 19, 1922; Hill, July 23, 1923; Lee, August 7, 1930; Rye, July 6, 1928. From grass and bushes.

Thamnotettix eburatus Van Duzee. Mt. Washington (base), September 7, 1920 (L. W. S.).

Thamnotettix belli (Uhler). Durham, May 12, June 12, 24, 1925. Swept from underbrush in opening in white pine-hemlock woods.

Thamnotettix belli var. *brunneus* Osborn. Durham, July 8, 1922. Swept from bushes.

Thamnotettix n. sp. (Near *perspicillatus* O. & B., sent to and retained by E. D. B.; I called this *Eutettix auratus* Ball). Durham, September 21, 1922, September 6, 15, 1924. From pitch pine.

Thamnotettix chlamydatus (Provancher). Bretton Woods, July 27, 1913 (C. W. J.); Glen House, Pinkham Notch, July 15, 1915 (C. W. J.); Mt. Washington, Halfway House, July 4, 1914 (C. W. J.), 2,500 ft. (C. W. J.); White Mountains, July 24, 1900 (W. F. F.), near base of Mt. Washington.

Thamnotettix melanogaster (Provancher). Durham, October 15, 1898 (W. F. F.), September 8–26, 1921, July 7–October 2. Common in low wet pastures and meadows, July 1, 9, August 1, 1923; Lee, August 7, 1930. In tall swamp grass.

Thamnotettix decipiens Provancher. Durham, September 20, 1922, September 19, 1924, September 7, 1927. From low meadow, sedge, edge of salt marsh.

Thamnotettix smithi Van Duzee. Durham, September 21, 1922; Webster, July 17, 1900. From damp meadow.

Thamnotettix fitchii Van Duzee. Durham, September 1, 1924, from tall grass at tide mark in salt marsh.

Thamnotettix inornatus Van Duzee. Alton, October 2, 1927; Durham, September 13, 26, 1921, August 29–October 5, 1922; Fabyans, September 2, 1928; Haverhill, October 7, 1927; Lee, August 7, 1930. Common on tall grass in swamp, or in low wet meadows.

Chlorotettix unicolor (Fitch). Common in meadows, pastures and on swamp grasses.

Chlorotettix spatulatus Osborn and Ball. Durham, August 15, 16, 1899, August 29, 1922; Concord, August 12, 1929; Lee, August 7, 1930. From tall grass in swampy region.

Chlorotettix tergatus (Fitch). Durham, August 1, 1898 (W. F. F.), August 18, 1899 (R. A. C.), August 6, 1900 (W. F. F.), September 8–30, 1921, August 29–September 14, 1922, August 11, 1923; Lee, August 7, 1930. From coarse grass in low meadows, pastures, swamps, along streams.

Chlorotettix galbanatus Van Duzee. Durham, August 30, 1922, July 1, 1923; reported for White Mountains—Fiske.

Chlorotettix balli Osborn. Durham, July 17, 20, August 30, 1922, August 11, 1923, August 28, 1924, July 31, 1925.

Chlorotettix lusorius (Osborn and Ball). Durham, October 14, 1922; Mt. Washington, reported (A. T. S., 1906) for alpine region.

Jassus olitorius Say. Center Harbor, September 10, 1914 (C. W. J.); Barrington, August 22, 1897 (C. M. W.); Durham, August 1, 1898 (W. F. F.), July 29, August 9, 15, 1899 (R. A. C.), July 19, September 14, 1921, August 27, 29, 30, September 25, 1922, August 11, 1923; Exeter, August 10, 1927; Lee, August 7, 1930; Wilton, August 22, 1928. On grape, corn, shrubs.

Paracoelidea tuberculata Baker. Durham, September, 1899 (W. F. F.), August 30, 1922, September 21, 1922, September 6, 15, 1924, August 18, 1927; Newmarket, August 31, 1922. Common on pitch pine.

Cicadula punctifrons var. *repleta* Fieber. Hanover, July 21, 1892 C. M. W.), July 6, 1908 (C. W. J.); Mt. Washington, reported for alpine region (A. T. S., 1897, 1902).

Cicadula variata (Fallen). Durham, June 28, 1900 (W. F. F.); Mt. Washington, near base, July 24, 1900 (W. F. F.); reported for alpine region (A. T. S., 1896).

Cicadula lepida Van Duzee. Durham, July 17, 1898 (W. F. F.), September 13, 1921, July 7–October 2, 1922, June 25, September 11, 1923; Nottingham, September 4, 1927. On *Impatiens*.

Cicadula sexnotata (Fallen). Common in meadows and pastures everywhere.

Cicadula pallida Osborn. Durham, September 23, 1922, June 28, September 4, 19, 1924; Spruce Hole, June 13, 1930. From bog herbs.

Cicadula divisa (Uhler). Mt. Washington, reported for alpine region (A. T. S., 1902).

Cicadula slossoni Van Duzee. Durham, September 8, 1921, July 8–October 2, 1922, July 9, 27, 1923; Mt. Washington, reported for alpine region (A. T. S., 1894), 6,200 ft., September 3, 1925; New Durham, October 2, 1927; Newmarket, August 31, 1922; North Hampton, September 13, 1922; Wonalancet, July 1, 1930. Common on *Juncus*.

Balclutha punctata (Thunberg). Common on grasses in meadows and pastures; also from grass in moist wood and from bog-herb zone.

Balclutha osborni Van Duzee. Mt. Clinton (near summit), July 31, 1900 (W. F. F.); White Mountains, from alpine summits of presidential range, July 26–28, 1900 (W. F. F.).

Balclutha impicta (Van Duzee). Durham, July 14–August 30, 1922, June 23, August 11, 1923; Hill, July 23, 1923; Mt. Clinton, near summit, July 30, 1900.

Eugnathodus abdominalis (Van Duzee). Dixville, September 9, 1930; Durham, September 16, 1921, July 14, September 7, 14, 1922; Hill, July 23, 1923; Isles of Shoals, July 22–28, 1929; Mt. Washington (near base), July 24, 1900 (W. F. F.); Raymond, July 13, 1930; Twin Mountain, July 28, 1900 (W. F. F.); Wonalancet, July 17, 1930, September 27, 1930.

Alebra albostriella var. *agresta* McAtee. Durham, July 14, 1922, August 11, 1923. From white oak (Det. W. L. M.).

Alebra albostriella var. *fulveola* (Herrick-Schaeffer). Durham, August 11, 1923, on white oak.

Dikraneura mali (Provancher). Chocorua Lake, September 1, 1928; Dixville, September 9, 1930: Durham, September 14, 22, October 3, 1921, June 5, July 11, 21, August 29, September 1, 8, 21, October 2, 1922, May 7, August 11, 1923; Lee, August 12, 1930; White Mountains, alpine summits, July 28, 1900 (W. F. F.).

Dikraneura fieberi (Loew). Common in meadows and pastures.

Dikraneura abnormis var. *urbana* Ball and DeLong. Durham, July 18, 20, 21, 1922, August 30, September 18, 1922; Hill, July 23, 1923; Newmarket, August 31, 1922; Wonalancet, July 17, 1930. Fairly common in moist meadow.

Empoasca maligna (Walsh). (*unicolor* (Gillette)). Apple Leafhopper. Durham, July 14, 20, 1922; Hill, July 23, 1923. On apple.

Empoasca smaragdula (Fallen). Durham, August 18, 1923, on willow.

Empoasca obtusa Walsh. Durham, September 14, 21, 1922, July 9, 1923; Mt. Washington, reported for alpine region (A. T. S., 1902).

Empoasca unica (Provancher). Durham, June 28, 1900, in trap lantern (W. F. F.), September 8, 22, 1921, July 7, August 30, 1922; Epping, June 27, 1898 (W. F. F.); Portsmouth, September 3, 1922; Webster, July 17-19, 1900 (W. F. F.). Common on alder.

Empoasca atrolabes Gillette. Durham, July 15, 17, 1898 (W. F. F.), August 29, 30, 1922, September 8, 1922, July 1, 1923; White Mountains, near base of Mt. Washington, July 24, 1900 (W. F. F.); Wonalancet, July 17, 1930. Common on alder.

Empoasca sp. (McAtee). Durham, September 22, 1921, August 30, September 21, 1922, July 18, 1923; Jackson, September 18, 1927. In dry bushy pastures.

Empoasca pergandei Gillette. Durham, September 14, 1921, July 18, 1923, September 7, 1927. On black locust. (Det. W. L. M.).

Empoasca coccinea (Fitch). Common on white and pitch pine.

Empoasca fabae (Harris). (*mali* (LeBaron)). Potato Leafhopper. Exeter, July 30, 1926; Lancaster, August 18, 1927; Madbury, September 8, 1927; Manchester, August 20, 1928. Potato.

Empoasca birdii Goding. Alton, October 2, 1927; Chocorua Lake, September 1, 1928; Durham, September 14, 1921, August 30, September 1, 7, 20, 25, October 14, 1922, May 9, 16, 20, 1925; Wonalancet, July 17, 1930.

Eupteryx melissae Curtis. Durham, July 9, 1925; Wilton, October 22, 1927. Common on catnip.

Eupteryx vanduzei Gillette. Durham, June 20, 1925; Hanover, July 8, 1908 (C. W. J.). Swept from ferns in white pine-hemlock forest.

Eupteryx flavoscuta var. *flavoscuta* Gillette. Chocorua Lake, September 1, 1928; Durham, September 30, 1921, August 29, October 14, 1922, June 12, 1925; Dixville, September 9, 1930; Hill, July 23, 1923; Holderness, reported (C. P. G., 1898); Mt. Washington (2,500 ft.), July 28, 1915. Common on ferns in white pine woods.

Eupteryx flavoscuta var. *juvenis* McAtee. Newmarket, August 31, 1922.

Eupteryx flavoscuta var. *clavalis* McAtee. Durham, September 30, 1921, July 14, 1922. From common wood fern.

Eupteryx flavoscuta var. *nigra* Osborn. Dixville, September 9, 1930; Durham, September 30, 1921, July 14, September 25, 1922; Hanover, July 8, 1908 (C. W. J.). From wood ferns.

Typhlocyba tenerrima Herrick-Schaeffer. Mt. Washington, reported for alpine region (A. T. S., 1898), (W. L. M., 1926—"has been unable to verify the reported occurrence of this species in America"). This is probably *T. unca* McA.

Typhlocyba piscator McAtee. Durham, June 23, 1923, (Det. W. L. M.).

Typhlocyba unca McAtee. Alton, October 2, 1927; Durham, September 8, 22, 30, 1921, August 30, September 7, 21, 1922, September 9, 1927 (Det. W. L. M.); Hill, July 23, 1923; Jackson, September 18, 1927; Mt. Washington (E. D. B.), male holotype (W. L. M., 1926). Common on alder.

Typhlocyba rosae (Linnaeus). Colebrook, September 9, 1930; Durham, September 13, 14, 15, 22, 1921, July 14, August 29, September 1, 11, 14, September 11, 13, 1923, August 20, October 3, 1924, September 25, 1925, September 7, 1927; Portsmouth, September 3, 1922. Common on roses, *Spiraea*, etc.; badly spotting apple leaves.

Typhlocyba lethierryi Edwards. Durham, September 9, 1927, (Det. W. L. M.).

Typhlocyba lancifer McAtee. Durham, July 5, 1923, from sugar maple, (Det. W. L. M.).

Typhlocyba cymba var. *cymba* McAtee. Alton Bay, July 27, 1930, in spider's web.

Typhlocyba cymba var. *pallens* McAtee. Chocorua Lake, September 1, 1928; Franconia, August 2, 1930, from red maple.

Typhlocyba cymba var. *unipuncta* McAtee. Jackson, September 18, 1927, (Det. W. L. M.).

Typhlocyba cymba var. *grata* McAtee. Mt. Washington (E. D. B.), recorded (W. L. M., 1926); Wonalancet, July 17, 1920.

Typhlocyba gillettei var. *gillettei* Van Duzee. Durham, July 17, 1898 (W. F. F.), July 5, 1899, at light (W. F. F.), June 21, 1900, from light (W. F. F.), September 30, 1921, July 14, September 7, (Det. (W. L. M.), 1922, August 11, 1923, September 9, 1927; Glen to Halfway House, White Mountains, July 8, 1891 (U. S. N. M.); Mt. Washington, reported for alpine region (A. T. S., 1896), (E. D. B., U. S. N. M.) and Waterville, July 17, 1906 (W. L. M., 1926); Nottingham, September 4, 1927; Ossipee, July 11, 1929. Fairly common on white oak and alders nearby.

Typhlocyba gillettei var. *suffrana* McAtee. Mt. Washington (E. D. B.), male holotype described from this locality (W. L. M., 1926).

Typhlocyba gillettei var. *casta* McAtee. Nottingham, September 4, 1927.

Typhlocyba gillettei var. *venusta* McAtee. Fabyans, September 2, 1928. From alder.

Typhlocyba pomaria McAtee. Durham, August 27, 1922, (Det. W. L. M.), August 21, 1924, (Det. W. L. M.), October 24, 1927, adults fairly common on apple; leaves show considerable white stippling; Wilton, August 11, September 30, October 22, 1927. Common on apple.

Typhlocyba arsinoe McAtee. Durham, August 30, 1922, (Det. W. L. M.).

Typhlocyba nitidula Fabricius. Mt. Washington, reported for alpine region (A. T. S., 1906). (W. L. M., 1926—"in the present study no species of the true *nitidula* has been found, and it is suggested that the Slosson record may be based on one of the varieties of *T. gillettei* or *T. cymba*.")

Typhlocyba modesta Gibson. Alton, October 2, 1927, (Det. W. L. M.); Jackson, September 18, 1927, (Det. W. L. M.).

Erythroneura vulnerata var. *vulnerata* Fitch. Durham, September 26, 1921, August 29, September 20, 1922, July 18, 1923, (Det. W. L. M.), September 13, 1923. On woodbine, grape.

Erythroneura niger (Gillette). Durham, May 7, 1923.

Erythroneura obliqua (Say). Common on underbrush in woods.

Erythroneura obliqua var. *eluta* McAtee. Durham, August 30, 1922.

Erythroneura obliqua var. *dorsalis* (Gillette). Durham, September 13, 14, 1921, (Det. W. L. M.), August 30, September 25, 1922. Taken from underbrush.

Erythroneura obliqua var. *stolata* McAtee. Durham, September 16, 1921, September 21, 25, October 14, 1922, (Det. W. L. M.).

Erythroneura obliqua var. *parma* McAtee. Durham, September 25, 1922, March 23, 1924, (Det. W. L. M.); Rochester, July 10, 1930, on blueberry.

Erythroneura obliqua var. *noevus* (Gillette). Durham, September 1, 1922, September 19, 1924.

Erythroneura obliqua var. *fumida* (Gillette). Durham, September 25, August 30, October 14, 1922, (Det. W. L. M.), September 19, 1924, May 12, 1925, (Det. W. L. M.).

Erythroneura obliqua var. near *clavata* DeLong. Durham, September 8, 23, 1922, August 28, September 4, 1924. Swept from bog shrubs where *Kalmia angustifolia* was dominant shrub.

Erythroneura abolla var. *varia* McAtee. Durham, September 14, 1921, (Det. W. L. M.), August 27, September 17, 1922, (De.. W. L. M.), September 7, 1927, (Det. W. L. M.). One yellow form from elm.

Erythroneura abolla var. new. Durham, September 16, 1921, August 30, 1922, May 12, 16, 1925; Mt. Washington, July 24, 1925, 2,500 ft. (C. W. J.).

Erythroneura tecta var. *carbonata* McA. Durham, September 22, 1921, (Det. W. L. M.), September 7, 11, 1922, (Det. W. L. M.).

Erythroneura scutelleris (Gillette). Durham, September 7, 1927, from American elm, (Det. W. L. M.).

Erythroneura basilaris var. *basilaris* (Say). Durham, September 8, 1922, (Det. W. L. M.).

Erythroneura maculata var. *maculata* (Gillette). Common on underbrush.

Erythroneura maculata var. *bigemini* McAtee. Durham, July 9, 1923, on willow.

Erythroneura maculata var. *gemina* McAtee. Durham, September 13, 14, 1921, July 8, October 2, 1922, August 21, 1924, (Det. W. L. M.); Dixville, September 9, 1930. Common on field and roadside shrubs.

Erythroneura vitis var. *vitis* (Harris). Durham, August 29, September 11, 1923, (Det. W. L. M.), September 13, 1923, on grape.

Erythroneura tricincta var. *tricincta* Fitch. Mt. Washington, reported for alpine region, (A. T. S., 1902).

Erythroneura comes var. *comes* (Say). Durham, September 3, 16, 1921, August 29, September 11, 1922, September 13, 1923; Wilton, October 22, 1927. Common on grape.

Erythroneura comes var. *vitifex* Fitch. Alton, October 2, 1927, (Det. W. L. M.); Durham, September 8, 1923, (Det. W. L. M.), June 12, 1925. On blueberry and shrubs.

Erythroneura comes var. *elegans* McAtee. Durham, September 26, 14, 1921, (Det. W. L. M.), July 18, 1923. Common on woodbine.

Erythroneura comes var. *ziczac* Walsh. Durham, September 26, 1921. From woodbine.

Erythroneura comes var. *rubra* (Gillette). Durham, September 7, 1922, June 24, 1925, September 13, 1923, on grape; Pinkham Notch, Glen House, June 11, 1916 (C. W. J.).

Erythroneura comes var. *rubrella* McAtee. Durham, September 14, 15, 16, 1921, August 27, September 1, 7, 14, 20, 1922, May 7, August 11, 1923, (Det. W. L. M.), September 29, 1927, on *Cornus*, (Det. W. L. M.); Rochester, July 10, 1930, on blueberry.

Erythroneura comes var. *nudata* McAtee. Durham, September 13, 1923, on grape associated with var. *comes*.

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NOTICE.

BOOK NOTICES

Fossil Brachyopods.

This extremely important work, which was started to include all Paleozoic brachiopods but because of the very immensity of the subject has had to be confined as yet to the genera of the suborders Orthoidea and Pentameroidea, is divided into five parts with an introduction and an appendix. Part I concerns itself with definitions of Brachiopod terms, a most needed assemblage. Part II considers the morphogenesis or evolution of form. Part III is the morphology of the Orthoid shell. Part IV describes and discusses the genera of the suborder Orthoidea, which are divided into 3 superfamilies, 23 families, of which Finkelnburgiidae and Tropidoleptidae are new, 18 subfamilies, 97 genera including Pomatotrema Ulrich and Cooper, and Clinambon, both new. With these numerous genera are 9 species of which 6 are new. Part V considers the genera of the suborder Pentameroidea, which are divided into 2 superfamilies, 6 families, 2 subfamilies, and 31 genera. In this part we find the morphology, generic and evolutionary trends of the suborder considered. The appendix considers the superfamily Rhychonellacea with 2 genera.

This excellent memoir represents the type of work which is so much needed to clarify the superabundance of names which are always appearing. This represents a study of the cream of the material gathered by Schuchert during his long period in Paleontology. Some 20 tables show the authors conception of the evolution trends of the genera and obscure points are illustrated by the text-figures. The Plate A illustrates Brachiopod morphology and the other 29 plates containing about 825 figures are of various specimens and show the excellence of the material studied.

It is a book that should be available in all Paleontological Libraries. My only regret is that more genera could not be treated and we hope that at a future date the authors will be able to make additional studies of the rest of the Paleozoic Brachiopods.—WILLARD BERRY.

Brachiopoda Genera of the Suborders Orthoidea and Pentameroidea, by Charles Schuchert and G. Arthur Cooper. Published as Memoir of the Peabody Museum of Natural History, Vol. IV, Part I, pp. i–xii, 1–270, Pls. A, 1–29, Tables 1–20, Text Figs. 1–36, 1932. Size 9½ x 12. $7.00.

Physical Geology.

This new text to replace that of Pirsson's should prove even more popular than the one it replaces. The manner of joint authorship in which each author handles that which lies most within his field coupled with careful editing makes for a text which does not unduly stress certain parts at the expense of other parts. The balance of the various chapters in amount and detail is excellent. Following each chapter is a list of "reading references" with a short evaluation of each. From the standpoint of illustrations this new text far surpasses the others. The illustrations are plentiful and well chosen. They are both half tones and line cuts of both the plane and block variety. The well selected use of aero photographs is to be commended on as they give the reader at a glance a comprehensive view of large areas. This is especially true in the case of glaciers and shore forms where land photographs fail to tell the entire story. An appendix on Minerals, one on Rocks and a third on Topographic maps should prove valuable as the student should have this information condensed in one place and not have to dig it out of several hundred pages of text.

This text appears to be easily "teachable" and is most certainly easily "readable."—W. BERRY.

Text-book of Geology, by C. R. Longwell, A. Knopf, and R. F. Flint. Part I. Physical Geology. 514 pp., 341 fig. New York, John Wiley and Sons, 1932. $3.25.

Rocks.

The author has done more than write "a combined text and laboratory guide" in this book. In the first part he deals with various criteria and methods; part II is devoted to the petrography of igneous rocks (114 pages); part III to the petrology of igneous rocks (117 pages); part IV to petrography of sedimentary rocks (45 pages); part V to petrology of sedimentary rocks (45 pages); part VI to petrography of metamorphic rocks (35 pages); part VII to petrology of metamorphic rocks (68 pages); and part VIII to minerals and selected readings (62 pages). Other selected readings accompany each chapter.

Geologists and students should welcome this book. Between its covers the three great groups of rocks are dealt with in a manner yet to be improved upon. Geologists should feel extremely fortunate that a man of Grout's experience could find time to put into one book, in such an expert manner, the results of his years of research and study. Anything but the most enthusiastic terms fail to express the quality of this great contribution. The author and publishers are to be congratulated on the production of this superlative work.—E. W. BERRY.

Petrography and Petrology (A Textbook), by Frank F. Grout. 522 pp., 265 ill. New York, The McGraw-Hill Book Co., 1932. $5.00.

The Physiology of Bacteria.

This is the title of a recent book by Prof. Otto Rahn. The word bacteria is used by the author not in its narrow taxonomic sense, but to include the yeasts as well. In fact the physiology of the yeasts occupies a prominent place in the discussions. Following the Preface and Introduction, the book is divided into four main parts, with the following headings: Endogenous catabolism, Energy supply of the cell, Growth, and Mechanism of death. Each of the last three parts is subdivided into a number of sections. A practical feature is the brief summary at the end of each chapter. A great deal of experimental data, much of it from original investigations by the author, is presented in the form of tables and graphs. There are in all 42 figures and 133 tables. There is a subject index and an author index to the papers cited in the text, but no attempt at a comprehensive bibliography is made. This book contains much of both fact and theory which should prove of interest to plant and animal physiologists, as well as to bacteriologists.—B. S. MEYER.

Physiology of Bacteria, by Otto Rahn, xiv + 438 pp. Philadelphia, P. Blakiston's Son & Co., 1932.

Experimental Pharmacology.

This small volume is a laboratory manual for students taking a brief course in experimental pharmacology. The material covered has been carefully selected and the experiments developed so as to emphasize specific features in the field of drug action. All non-essentials have been eliminated and the methods simplified. In carrying out this simplification the author assumes that the students have already had previous experience and training in physiological studies and manipulation and are therefore familiar with basic routine procedures. On the other hand certain features of pharmacologic technique, such as the various methods of administration of drugs and the use of the hypodermic syringe are described and discussed.

The experiments are selected to illustrate the general action of the drug and frequently to emphasize certain general principles involved. In these instances certain features are specifically mentioned such as "pathological pharmacology," toxicological action, pharmacological analysis, types of anesthesia, absorption, excretion, as well as the fate of drugs in the body. Certain bio-assays such as illustrated by the U. S. P. assay for digitalis are also given as examples of specific problems.

Noteworthy features which may be mentioned are the questions asked under each experiment, the special tests given, and the numerous references to the current literature.

Another noteworthy feature is the chapter addressed to the student in which three features are emphasized:

(1) "The preparation of the mind as well as the materials."
(2) "The laboratory procedure."
(3) "The analysis and interpretation of results."

The text is to be highly commended as a laboratory guide in a general course.
C. A. DYE.

Experimental Pharmacology and Toxicology, by Henry G. Barbour, M. D. Philadelphia, Lea and Febiger, 1932.

More About Evolution.

The third edition of this work has just come from the press. Originally a book of selected readings, subsequent editions have approached nearer to the nature of the text. The present edition is very usable as a genetics and evolution text. While some chapters are still made up of selections from the writings of others, Newman himself has coordinated and unified them by the addition of chapters and sections from his own pen. Following an opening discussion of the historical background of the evolutionary theory, the specific evidences are carefully discussed. A considerable part of the book is given over to the mechanism of evolution, that is, genetics. A very clear discussion of eugenics and human heredity makes the book of especial value to today's student.—L. H. S.

Evolution, Genetics and Eugenics, by H. H. Newman. xxix + 620 pp. Chicago, the University of Chicago Press, 1932. $3.50.

Insects and Disease.

The rapid advance in knowledge concerning the relations of insects and other arthropods to human health and disease, together with the widely scattered literature, necessitate frequent summaries of the available facts. This volume is an excellent account of the modern conceptions of insects and disease, and will be indispensable to the physician and public health worker, as well as to the entomologist. The interested layman will find it readable and authentic. Many fine illustrations add to its value, and the extensive bibliography will be greatly appreciated. The newly-developed use of blowfly larvae in osteomyelitis is discussed, as well as other recent developments.—L. H. S.

Medical Entomology, by Robert Matheson. xii + 489 pp. Springfield, Illinois, Charles C. Thomas, 1932.

How We Grow.

Julian Huxley has written a most interesting account of growth and growth processes, which considerably reinforces the rather scanty foundation upon which many of our ideas of development have been built. Growth gradients are thoroughly discussed, and their widespread existence established. Especially illuminating are the application of gradients to the various morphologic variations of related groups, by means of Cartesian transformation. No biologist can afford to miss this book.—L. H. S.

Problems in Relative Growth, by Julian Huxley. xix + 276 pp. New York, The Dial Press, 1932.

Thinking Machines.

The cordial reception accorded the first edition of this work has necessitated a second edition, in which some corrections have been made and some new material added. The book is a delightful compendium of the mechanistic basis of human behavior, with a sound psychological and philosophical background. As such it merits the attention of all those interested in any phase of human biology.
—L. H. S.

The Thinking Machine, by C. Judson Herrick. xii + 374 pp. Chicago, The University of Chicago Press, 1932. $3.00.

Mammals, Good and Bad.

The literature on economic mammalogy has been scattered through such a wide range of publications that it is a pleasure to have it brought together under one cover. The present volume, although rather naively written, adequately summarizes the available information. The first part of the book is a general discussion of the varied ways in which mammals may affect human welfare. The second part is a systematic discussion, taking up in turn each order and family. This part will be of especial interest to the scientist. Not only is an excellent bibliography appended, but the particular page in question is cited in addition in footnotes. The binding and make-up are exceptionally fine.—L. H. S.

Economic Mammalogy, by J. Henderson and E. L. Craig. x + 397 pp. Springfield, Illinois, Charles C. Thomas, 1932.

Our Mineral Civilization.

Those who have come under the spell or influence of Technocracy (the machine age) will find in this little volume a wealth of interesting statistics. The book deals largely with the development and use of our mineral resources and the influence of the invention of modern machinery on the demand for certain metals or inorganic compounds. The presentation of this story of the rise in importance of our minerals is both entertaining and instructive. It has been written in a non-technical manner, but should be just as interesting to the scientist as to the layman.—Wallace R. Brode.

Our Mineral Civilization, by Thomas T. Read. 165 pp. Baltimore, The Williams and Wilkins Co., 1932. (One of the Century of Progress Series.)

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MYELIN STRUCTURES IN LIPOIDS AND THEIR RELATION TO ELECTRIC CHARGES.

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In a paper by Dr. G. W. Crile (1), reference is made to the myelin structures which grow out from lipoid films covered with various solutions. It was observed that the application of electrical polarization increased the growth of these myelin structures. In this paper further studies are published with the aim of correlating the growth of myelin structures with other physical properties.

The formation of myelin structures was first described by Virchow (2) in 1854. Haeckel (3) assigned an important role to these structures in vital phenomena; Lehmann (4) and Rhumbler (5) made further experiments. Recently Leathes (6) investigated the myelin structures formed by various lipoids. He took moving pictures of their growth and influenced the rate of growth by applying various salt solutions in different concentrations. It appeared that concentrated salt solutions retarded growth, while more dilute solutions stimulated it. Calcium salts inhibited growth. Various types of structures were obtained in solutions containing gelatin, egg white, serum hemoglobin, etc., and with mixtures of lecithin and cholesterol.

In our own investigations an attempt was made to bring this phenomenon into relationship with the electrical surface charge of thin films of lipoids. The basis for expecting that such a relationship is possible is the known fact that in thin lipoid films an orientation of the fatty acid molecules takes place (Leathes (7) and Adam (8)). The fatty acid group is attracted toward the water, while the methyl group of the paraffin chain is directed away from it. The fatty acid chains are arranged

parallel to each other, each lecithin molecule for instance occupying a surface of 56 square Å, according to Leathes' measurements on thin films spread over water. Trillat (9) found a similar parallel arrangement of fatty acid molecules with the Hull-Debye-Scherrer x-ray method. On films spread over metals he found that the distance between the lecithin molecules averaged 47 Å, which is a somewhat higher value than for films spread over water. Further indications of the polar arrangement of lipoid molecules are shown by the model experiments of Runnstorm (10) in which the molecules show double refraction and striated lamellae under the polarization microscope.

Actual measurements of the surface charge of cholesterol sols were made by Remesow (11) by the cataphoresis method, which gave interesting results; this method, however, could not be applied to lecithin emulsions.

In seeking a possible explanation for the formation of myelin structures the following observation is of value. The myelin structure is always surrounded by a thin film (Fig. 2B) while the inside of the structure is filled with liquid. In a dry particle of lipoid the fatty acid chains are necessarily orientated at random. If this particle is then surrounded with pure water, an immediate rearrangement of the fatty acid chain takes place in such a way that the acid ends point toward the water, while the paraffin ends point toward the inside of the particle. Water passes through between the orientated fatty acid chains, and consequently the surface of the lipoid particle begins to enlarge, long myelin structures rising out of the lipoid. The growth velocity of the myelin fibers must necessarily depend on the velocity with which the water penetrates through the surface film and increases it. This phenomenon might be explained as being due to various physical causes, like diffusion, swelling (similar to that of proteins), osmosis, surface tension, etc. This will be discussed later.

EXPERIMENTAL METHOD.

To avoid the difficulty of working with lecithin an ether extract of calf's brain was used. The tissue was thoroughly minced, rapidly dried at a temperature not exceeding 40° C. (higher temperatures lessen or inhibit the growth of myelin structures). The dried tissue was pulverized, extracted with ether, and filtered several times. This solution can be kept

for several weeks. Extracts which were over a month old were not used. The concentration of the ether solution was determined by evaporating a known amount of the solution to dryness under vacuum. Generally the ether solution was so diluted as to contain one per cent lipoid.

The growth of the myelin structures was observed in the following way. A well slide (similar to those used in tissue cultures) was thoroughly cleaned and a drop of the ether solution was deposited on it by means of a glass rod. The drop was of such dimensions that it corresponded to 0.1 cc. of the one per cent lipoid solution, containing therefore about 1 mg. of lipoid. The drop was deposited so that it formed a round, thin film about 5–7 mm. in diameter. The ether evaporated very rapidly, leaving a very thin film, which was generally somewhat thicker around the edge. This film was covered with several drops of the solution, the effect of which was to be tested, and a cover glass was placed over it. Slight pressure on the cover glass expelled the excess of liquid, which was blotted off, leaving a preparation which without drying could be observed over a period of several days. Vaseline or other sealing material was found to be unnecessary.

On account of the thinness of the film, the growth of myelin structures could be observed not only on the edge of the film, but throughout its surface. The standard comparison of growth was made with the help of a solution which contained the salts found in the brain dissolved in distilled water in the same proportion as they are present in the brain. The composition of 1000 cc. of this "brain-salt" solution was as follows: KCl—2.33 gm., Na_3PO_4—2.21 gm., K_3PO_4—0.89 gm., Na_2CO_3—0.11 gm., K_2SO_4—0.24 gm., $CaCl_2$—0.026 gm., $MgCl_2$—0.55 gm., distilled water to make 1000 cc. The calcium and magnesium salts formed a precipitate with the phosphate, which was filtered off. This solution was alkaline—pH 11.4. Myelin structures were readily formed in this solution. Immediately after a lipoid film was covered with this solution, small myelin growths appeared, not only on the edge of the film, but all over its surface. With a magnification of 600 the growth of the structures could be observed and with the aid of an ocular micrometer the growth could be readily followed.

In order to compare the effects of solutions of various salts in distilled water, a number of well slides were covered with the thin lipoid film; the various solutions were superimposed

as quickly as possible and the growth of the myelin structures was observed under the microscope at intervals of 5, 10 and 30 minutes. The results are given in Table I in which the best growths (that is, one comparable to that in the brain-salt solution) are indicated by xxx, medium growths by xx, slight growths by x and no growth at all by —.

TABLE I.

Growth of Myelin Structures in Various Solutions.

Solution	Concentration of Solution in Mols.					
	1	0.1	0.01	0.001	0.0001	0.00001
NaCl	—	x	xx	xxx	xxx	xx
KCl	—	x	xx	xx	xx	xx
$CaCl_2$	—	—	—	x	xx	xx
$MgCl_2$	—	—	—	x	xx	xx
$CuCl_2$	—	—	—	x	xx	xx
$FeCl_3$	—	—	—	—	x	xx
HCl	—	—	—	—	x	x
NaOH	x	xx	xx	xxx	xx	xx
K_3PO_4	x	xx	xx	xxx	xxx	xx
K_2SO_4	x	xx	xxx	xx	x	x
KCN	x	xx	xxx	xx	x	x
NaI	x	x	xx	x	x	x
Na_2CO_3	x	xx	xxx	xx	x	x

In solutions of the chlorides the growth increased in direct relation to the degree of dilution. The bivalent salts inhibited growth in 0.01 molar solutions and the trivalent $FeCl_3$ inhibited growth even in 0.001 molar solutions. No growth was observed in acid solutions except in those in which the pH was above 3.6, while NaOH and K_3PO_4 favored growth even in higher concentrations. Anions such as SO_4, CN, CO_2 seemed to favor growth as compared with Cl.

The characteristic growths produced by different concentrations are indicated in Fig. 1, which shows the effect of (A) n, (B) 0.01n and (C) 0.001n NaCl solutions on the growth of myelin structures; while Table I gives the approximate grades of growth (—, x, xx, and xxx, respectively). Non-electrolytes have a marked influence on growth. For instance, an xx growth appears in a 10 per cent solution, glucose and even a saturated solution of glucose is not able to stop growth. Various dilutions of ethyl alcohol also exhibit a marked influence.

FIG. 1. Photomicrographs showing the effect of NaCl solutions on the growth of myelin structures.

A: n NaCl, growth—cataphoretical charge, 0 millivolt.
B: 0.1 n NaCl, xx, cataphoretical charge, —51.
C: 0.001 n NaCl, xxx, cataphoretical charge, —87.

In mixtures of salt solutions an antagonistic effect can be observed. If a growth-inhibiting solution of $CaCl_2$ is mixed with a growth-favoring solution, a fair growth of structures can be seen. In order to compare the antagonistic effects of various solutions, a further series of observations was made by dissolving the various agents in the "brain-salt" solution instead of in distilled water (Table II). In this way the action

TABLE II.

GROWTH OF MYELIN STRUCTURES IN A MIXTURE OF VARIOUS SOLUTIONS WITH THE BRAIN SALT SOLUTION.

Solution	Concentration of Solution in Mols.				
	1	0 1	0.01	0.001	0.0001
NaCl	x	xx	xxx	xxx	xxx
KCl	x	x	xx	xxx	xxx
$CaCl_2$	—	—	x	xx	xxx
$MgCl_2$	—	—	x	xx	xxx
$FeCl_3$	—	—	—	xxx	xxx
$AlCl_3$	—	—	—	xxx	xxx
NaI	xx	xx	xx	xxx	xxx
NaBr	xx	xxx	xxx	xx	xxx
	Concentration of Solution in Per Cents				
	1	0.1	0.01	0.001	0.0001
Adrenalin	....	x	xxx	xx	xxx
Atropin	x	xx	xxx	....	....
Caffein	xxx	xxx	xxx	....	....
Luminal	xx	xx	xxx	....	....
Strychnin	x	xx	xx	xxx	....
Ethyl alcohol	x 50%	xxx 25%	xx 10%	xxx 2.5%	....
Formaldehyd	— 40%	x 10%	xx 1%	xxx 0.1%	....
Glucose	x 20%	xx 10%	xxx 1%	....	....

of the agents is observed in the same salt solution as that which is present in the brain, although it is in no way implied that in this way a comparison between the effect of agents on the lipoid emulsion and on the brain could be made directly.

Some of the metal chlorides form a precipitate with the phosphate, etc., which results in the removal of the added metal ions from the solution. As shown in Table II, however, the salts exert a marked influence although their inhibiting action

in the higher concentrations is counterbalanced by the "brain-salt" solution.

The effect of alcohol is shown in Fig. 2. The inhibiting effect of a 50 per cent solution (C), and the accelerating effect of a 25 per cent solution (B) is evident. The inhibiting effects of some of the other agents in relatively low concentrations are remarkable.

CATAPHORESIS MEASUREMENTS.

A slightly modified Northrop cataphoresis apparatus was used. The current was conducted through reversible electrodes. The charge of the particles was calculated from the Helmholtz-Schmoluchowski formula. With concentrated solutions the viscosity of the solution was also taken into account.

The emulsion was obtained by drying some lipoid thoroughly and mixing it with the solution to be tested. After mixing, the usual myelin formations grew out of the mass of lipoid and when the mixture was shaken for some time the longitudinal parts of the long myelin structures could be seen floating in the mixture. When the mixture was shaken vigorously, the myelin structures were broken up into oblong tubular particles which were filled with liquid. The length of these particles was generally about $20\mu\mu$, although some larger particles were found occasionally. When the suspension was allowed to stand for several hours practically the whole of the lipoid was changed into such particles.

Another method for preparing emulsions was to mix the ether solution of the lipoid with distilled water or the salt solution to be tested. As much of the ether as possible was evaporated under reduced pressure at a temperature of 40° C. In this way a suspension of round globules was obtained, in which a rapid growth of myelin structures could be seen.

The emulsion of myelin structures was placed in the cataphoresis apparatus and the velocity of the particles in an electric field was measured with a stop watch. The necessary precautions in regard to differences in the charge in the capillary tube were taken by always measuring the velocity at the same level of the capillary; in this way all the observations could be compared. While there might be some theoretical objection to the use of the formula, as the charge was always calculated from the same formula only relative values were compared. Some authors prefer to give the cataphoretical velocities as measured directly.

FIGURE 2.

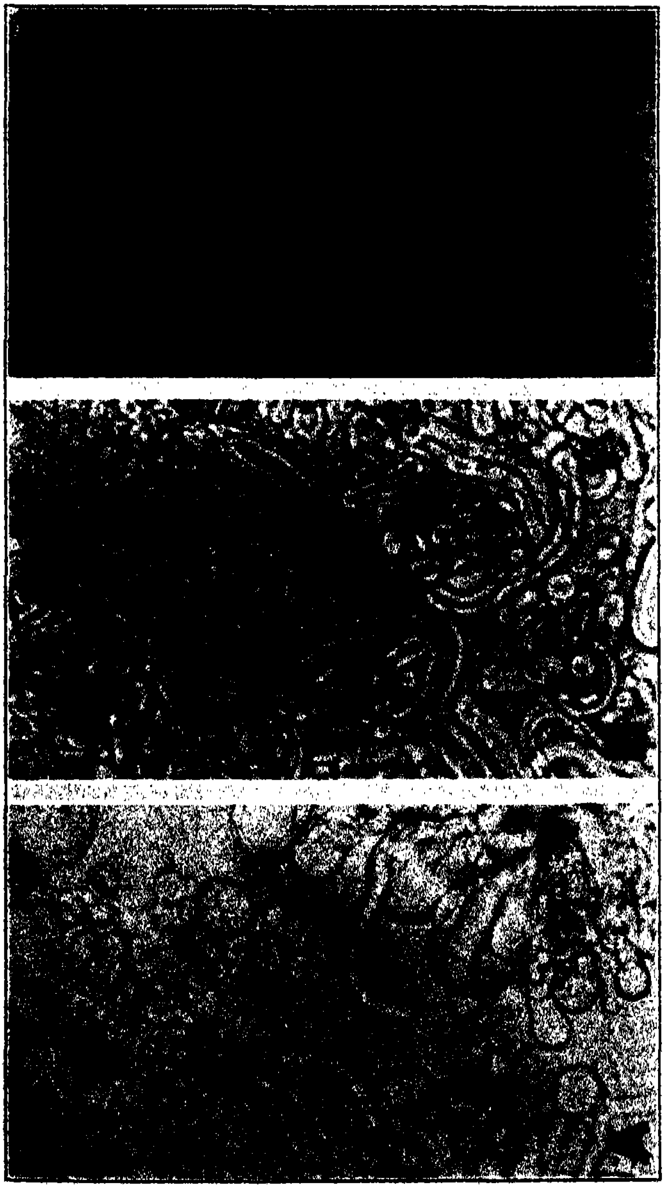

FIG. 2. Photomicrographs showing the effect of ethyl alcohol solution on the growth of myelin structures.

A: 10 per cent solution growth xxx, cataphoretical charge, —62 millivolts.
B: 25 per cent solution xxx, cataphoretical charge, —75.
C: 50 per cent solution x, cataphoretical charge, —18.

In Table III are given the charges in millivolts of myelin particles in the various solutions. The charge of the lipoid in distilled water alone is —78 millivolts. Very dilute salt solutions increase the charge, while concentrated salt solutions generally decrease the charge until the particles become discharged or their charge is even reversed. The best method of observation was to prepare a suspension in distilled water.

TABLE III.

GROWTH OF MYELIN STRUCTURES IN VARIOUS SOLUTIONS COMPARED WITH THEIR ELECTRIC CHARGE (MILLIVOLTS).

SOLUTION	CONCENTRATION OF SOLUTIONS IN MOLS.							
	1	0.5	0.1	0.01	0.001	0.0001	0.00001	H_2O
NaCl	— 0	— —11	x —51	xx —85	xxx —87	xxx	xx	......
KCl	— 5	— 0	x —43	xx —63	xx —73	xx	xx	......
$CaCl_2$	— 7	— 0	— 0	— —17	x —49	xx	xx	......
$CuCl_2$	—	—	—	— 0	x —46	xx —61	xx —70	xx —68
$FeCl_3$	—	— 0	— 38	— 66	— 0	x —49	xx —51	xx —70
NaOH	x —12	xx	xx —48	xx —91	xxx —108	xx —84	xx —89	xx —98
K_3PO_4	x —15	xx	xx —36	xx —62	xxx —111	xxx —94	xx —78	xx —100
Ethyl alcohol	50% x —18	25% xxx —75	10% xxx —62	1% xx —43	......	......	......	......
Urethane	1% — —17	0.1% x —36	0.01% x —47	0.001% — —18	......	......	......	......

The cataphoresis cell was filled with the emulsion and the velocity of the particles determined; a sufficient amount of salt solution was then added, the emulsion was mixed in an attachment of the cataphoresis cell and the velocity determined again without removing the emulsion from the apparatus. In this way, successive concentrations of the same salt were determined for their effect in changing the electrical charge.

In distilled water the whole amount of the lipoid changes very quickly into myelin forms. If subsequently an agent is added which discharges the particles or reverses their charge, the small structures shrivel up or change into shapeless masses, the velocity of which may still be determined. On the other

hand, if the discharging agent is added directly to a compact mass of lipoid, no myelin formation occurs generally, and so it is impossible to measure the change of the charge.

The peculiar changes observed are similar to those found by Heesch (12), by Remesow (11) in observations on cholesterol particles and by Brown and Broom (13) in observations on bacteria. Nevertheless such changes are not characteristic of lipoid alone, as various other suspensions show similar changes in the charge during the influence of bivalent and trivalent salts. Obviously, a surface charge or a potential difference will not produce myelin structures in most substances, but naturally the conclusion will be drawn from Table III that *the growth of the myelin structures is proportional to their negative electrical charge*, in the solutions which were used in our experiments.

INFLUENCE OF GALVANIC CURRENT ON THE GROWTH OF MYELIN STRUCTURES ON A LIPOID FILM.

If the growth of myelin structures in various salt solutions is proportional to the electric charge or electric potential difference between the film and the salt solution, then it should be possible to increase this potential difference by applying a constant galvanic current through the film. In such a case an electric polarization will result on the film, which will act as an increased charge. The following experiment was conducted. A microscopic slide was equipped with two reversible electrodes (silver needles covered electrolytically with silver chloride) which were separated by an interval of about 1 cm. A small drop of lipoid was placed between the electrodes, and a few drops of "brain-salt" solution were superimposed, so that the solution covered the electrodes. An electric current of about 1.5 volts was then passed through the solution. The myelin structures immediately began to grow rapidly all over the drop of lipoid bending towards the positive pole of the applied current. The growth was compared with that observed in an entirely identical drop in an experiment which was made under the same conditions and at the same time, except that in the latter experiment the electrodes were omitted. B and C in Fig. 3 show the growth with and A without electrical polarization. It will be noted that the structures point directly towards the positive pole. These experiments show not only that the growth is proportional to the negative charge of the

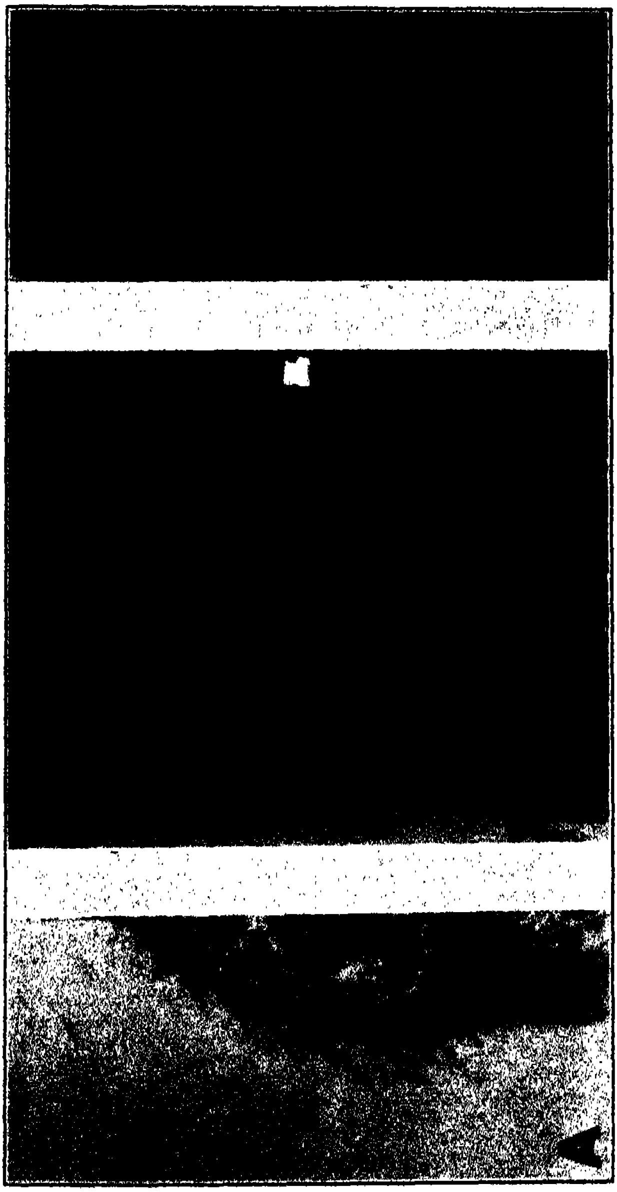

Fig. 3. Photomicrograph showing the effect of electrical polarization on the growth of myelin structures.

A: without polarization. B and C: with polarization.

Note the direction and bending (in C) of the myelin structures toward the positive pole of the applied current.

myelin structures in the various salt solutions, but also that in the same salt solution an artificially increased charge will produce a very much increased growth.

MEASUREMENTS OF SURFACE TENSION AND VISCOSITY.

The surface tension of the lipoid suspension was measured with Traube's stalagmometer and parallel measurements of viscosity were made with a capillary viscosimeter. The procedure was as follows: The viscosimeter was filled with the lipoid suspension (1 per cent lipoid in distilled water). The determinations were made, and the same sample was then transferred to the stalagmometer and surface tension readings were taken. The solution, the effect of which was to be tested, was then added to the suspension and the surface tension and viscosity determined again on the same sample.

TABLE IV.

GROWTH OF MYELIN STRUCTURES COMPARED WITH THE ELECTRIC CHARGE OF THE LIPOID AND THE SURFACE TENSION WITH AND VISCOSITY OF THE LIPOID EMULSION.

MATERIAL	RELATIVE SURFACE TENSION	RELATIVE VISCOSITY	ELECTRIC CHARGE MILLIVOLT	GROWTH
Lipoid suspension in distilled water	0.76	1.00	—98	xx
Same in 0.0001 n NaOH	0.89	1.08	—84	xx
Same in 0.001 n NaOH	0.93	1.00	—108	xxx
Same in 0.01 n NaOH	0.88	0.95	—91	xx
Same in 0.1 n NaOH	0.83	0.92	—48	xx
Same in 0.2 n NaOH	0.92	0.95	—40	xx

The relative values of the viscosity, surface tension, the electric charge in millivolts and the observed growth of myelin structures are compiled in Table IV. Values are given only for a lipoid suspension in NaOH solutions, as this is sufficient to illustrate that there is no relation between the surface tension or the viscosity and the growth of myelin structures. Other measurements were made with electrolytes and non-electrolytes.

DISCUSSION.

As was mentioned above, the basic explanation for the growth of myelin structures is that water actually penetrates through the lipoid-water interface. Such a penetration might be explained possibly by the presence of various physical changes like osmosis, diffusion, surface tension, etc. If this is true,

then the changes of the physical constants must result in a considerable difference between the effects of different solutions, as for example of NaCl and HCl, and furthermore the constants must change considerably with the dilution, as for example in n and in n/100 NaCl. It is evident that there is no proportionality between the physical properties of the solution and the growth of myelin structures.

SUMMARY.

1. The growth of myelin structures in lipoid extracts of mammalian brain was found to depend on the concentration of the solution. No myelin growth took place in concentrated solutions; with increasing dilution the growth reached a maximum and slightly decreased again with greater dilution.

2. Bivalent salts have a considerable inhibiting action even in n/100 molecular solutions, while trivalent salts inhibit growth even more.

3. An antagonistic action was found to take place in mixtures of salt solutions.

4. The growth of myelin structures is proportional to their negative electrical charge.

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DIGESTION IN BLOWFLY LARVAE, PHORMIA REGINA MEIGEN, USED IN THE TREATMENT OF OSTEOMYELITIS.*

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The role of digestion in blowfly larvae is closely associated with the use of these maggots in the treatment of osteomyelitis. It is interrelated with such factors as methods of aseptic rearing, food requirements, and the activities of these maggots within the wounds involving the success of the treatment. In this study emphasis was placed on the qualitative determination of enzymes present and their location in the digestive tract, the effect of bacteria on digestion, and the analysis of the excreta.

Many articles have been written about digestion in various flies, most of the investigators attempting to prove or disprove the necessity for the presence of bacteria in the food. Atkin and Bacot (1917) maintained that bacteria or yeast was necessary in the food of the mosquito *Stegomyia fasciata*. Baumberger (1919) showed that Drosophila could not be raised without live yeast. According to Bogdanow (1906 and 1908) Calliphorid larvae failed to develop in the absence of micro-organisms. Guyenot (1906, 1907, and 1917) stated that Lucilia lived on the liquid products of bacteria, were unable to produce digestive ferments, and that this was done for them by bacteria. On the other hand, Wollman (1911) maintained that Calliphorid larvae could be raised without the presence of bacteria. Glaser (1924) bred two generations of Drosophila on aseptic yeast, and Northrup (1926) succeeded in rearing 230 generations of Drosophila aseptically. Hobson (1932a) raised larvae of *Lucilia sericata* aseptically on autoclaved sheep's brain, but was not successful when he used types of muscle such as that found in a guinea pig or a cod (1932b).

* One of a series of research projects done as a part of the study upon the use of fly larvae in the treatment of osteomyelitis being made by the Department of Zoology and Entomology under the direction of D. F. Miller, in co-operation with the Departments of Medical and Surgical Research and of Orthopedic Surgery, in the Ohio State University.

A few articles have been written concerning the digestive enzymes present in various flies. Bogdanow (1928) succeeded in breeding eleven continuous generations of *Calliphora erythrocephala* on human excreta and concluded that this fly built up proteins from simple nitrogenous compounds and amino acids. Trypsin was found in the excreta of Calliphorid larvae according to Weinland (1906). Protease, amylase and erepsin in Calliphorid and Lucilia larvae were found by Wollman (1922). Probably the most complete work on digestion of flies was done on *Lucilia sericata* by Hobson (1931), who found traces of amylase in the salivary glands while tryptase, peptidase and lipase were found in the midgut. Proteolytic enzymes were also found in the excreta.

PREPARATION OF MATERIALS FOR ENZYME TESTS.

Full grown *Phormia regina* larvae which had not yet ceased to feed were used throughout the tests. They were starved until their alimentary tracts were empty by placing them in a specially prepared filter that provided for a slow stream of water to pass over them. This procedure, similar to that devised by Hobson, not only kept the larvae moist during starvation, but it also prevented the ingestion of excreta. The alimentary canals of larvae treated in this manner were usually perfectly clean within 6 to 8 hours, and by this method we were certain that any positive tests obtained would be from enzymes located in the tissues of the larvae.

The digestive tracts were then removed from the larvae, after which glycerol extracts were made separately of the salivary glands, crops, anterior-middle- and posterior-portions of the mid-intestines, and hind intestines. The organs, as well as the division of the mid-intestine into three parts, are shown in Figure 1, which illustrates the gross anatomy of *Phormia regina*, having a digestive tract essentially the same as that of *Calliphora erythrocephala* (Lowne, 1890) and *Lucilia sericata* (Hobson, 1931).

When fifty larvae were so dissected each of the various portions was completely macerated in a mortar and stored in vaccine tubes under toluene.

Preparations from the excreta were made by placing one hundred washed larvae in the filter, and allowing 50 cubic centimeters of water to drip over and through them for four hours. This solution was then stored in a similar manner by

placing it in vaccine tubes under toluene. The possibility of regurgitation was not eliminated by this procedure, but this was not essential since we desired to determine all the digestive enzymes emitted by the larvae, as they would all be present in the treatment of a wound.

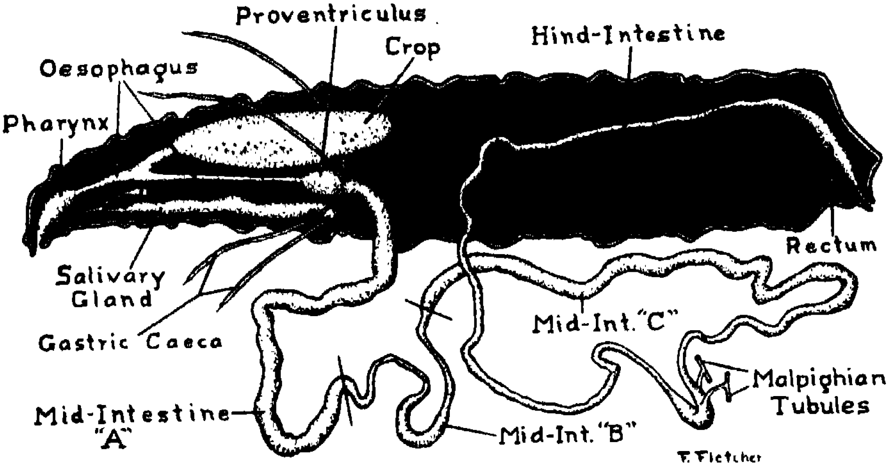

FIG. 1. Gross anatomy of the Blowfly larva, *Phormia regina* Meigen.

DETECTION OF ENZYMES AND HYDROGEN-ION CONCENTRATION.

The methods of enzyme analysis were essentially those devised by Swingle (1928) with certain modifications being made according to Wigglesworth (1927, 1928 and 1929) and Hobson (1931). A very brief summary of the methods used were as follows:

Amylase was tested for by glycerine extracts acting upon .5 cc. of 0.5 per cent starch solution, potassium iodide added after 72 hours incubation at room temperature. The Flückiger test was used to detect the presence of reducing sugars. *Maltase* was tested for by adding glycerine extracts to a 15 per cent solution of maltose, incubated for 72 hours, and the osazone test used to determine the presence of glucose. The test for *Invertase* was the addition of the glycerine extract to 0.5 cc. of 15 per cent solution of sucrose, and, after 72 hours incubation, the presence of fructose and glucose tested by using the osazone test and the presence of reducing sugars by the Fluckiger test. The test for *Lactase* was the same as that for maltase with the exception of using a 3 per cent lactose solution as the

substratum. *Lipase* was tested for by using the Brom Thymol Blue Emulsion test. An emulsion of olive oil and acacia was added to the glycerine extract in which the presence of Brom Thymol Blue and lipase would cause a color change from blue to greenish-yellow after 96 hours incubation. *Trypsin* and *Pepsin* were tested for by using the blood fibrin test as outlined by Swingle, the enzymic action breaking down the fibrin previously stained with Ruthenium Red for the trypsin test, and stained with Amaranth for the pepsin test. *Erepsin* was tested for by using the Modified Sorensen Method as outlined by Swingle.

TABLE I.

Digestive Enzymes in Contaminated Larvae of *Phormia regina* Meigen.

Enzyme	Salivary Glands	Crop	Anterior Mid-gut	Middle Mid-gut	Posterior Mid-gut	Hind Gut	Excreta
Amylase	±	—	—	—	—	—	—
Maltase	—	—	—	—	—	—	—
Invertase	—	—	+	—	—	—	—
Lactase	—	—	—	—	—	—	—
Lipase	—	—	±	—	±	±	±
Trypsin	—	—	+	—	+	+	+
Pepsin	—	—	—	—	—	—	—
Erepsin	—	—	+	—	+	±	±
pH	7.18	7.24	7.15	6.0	7.18	7.54	7.1

The hydrogen-ion concentration was determined in the various portions of the digestive tract as well as the excreta. The fluids from the tracts of freshly-killed larvae were taken up in small capillary tubes, indicators added and the resulting colors compared with a similar set of capillary tubes made up with standard indicators. This method was checked by using a standard micro-comparator set.

The results obtained are indicated in Table I. The plus sign (+) represents a relatively strong reaction, while the negative sign (—) indicates no reaction, and the two signs together (±) point out a weak reaction. These tests were repeated in three different sets of experiments and only once was the presence of *invertase* indicated.

EFFECT OF BACTERIA ON DIGESTION.

A technique was devised for the rearing of aseptic larvae. This was thought advisable for two reasons: first, that it offered a check on controversial results of former investigations, and second, that it provided a means of proving that whatever digestion occurred was due to enzymes present and not to bacteria. Fresh lean beef was ground up and weighed into 12-gram amounts and placed in large test tubes that had been previously autoclaved. This set-up was then heated in a water bath at about 75° C. for 30 minutes on four successive days, thereby killing off the vegetative stages of any bacteria that might have developed after the first and second heatings.

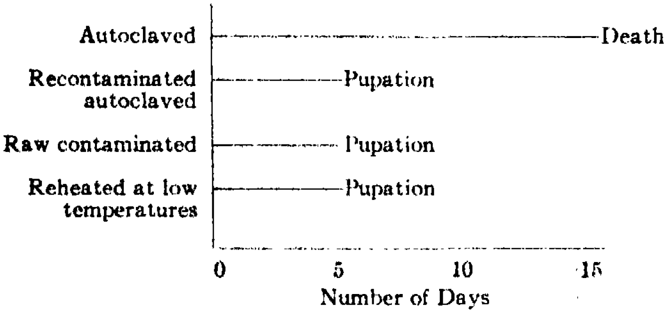

FIG. 2. Rate of development of larvae on varied treatments of the same medium.

After this part of the procedure was finished eggs of *Phormia regina* were implanted that had been previously sterilized by washing them in an alcoholic solution of 1 : 2000 mercuric chloride, about 30 eggs placed in each tube. Check tubes on rate of development were made by placing raw contaminated beef in one tube, recontaminated autoclaved beef in the second, and sterile autoclaved beef in the third. The larvae were allowed to grow without any disturbance of the sterile cotton plugs that closed the test tubes. After the larvae had become full grown, the contents of the test tubes were examined for bacterial contamination by implanting small portions of them in anerobic and aerobic broth tubes, on agar plates, and by stained smears on microscope slides.

The maggots in those tubes that proved to be sterile were then divided into two lots. The larvae of the first lot were allowed to continue their development, and the flies that

emerged were full size and seemed normal in every respect. Some rather significant results were obtained when the rate of development of these larvae were compared with those reared in the check tubes. Figure II illustrates these results graphically, carried only through the feeding period (Haub and Miller, 1932).

At a constant temperature of 29° C., and a relative humidity of 70 per cent, maggots grown in the media made sterile by this low heating method pupated on the fifth day. The same rate of development occurred in those tubes containing raw contaminated beef and recontaminated autoclaved meat. Those maggots grown in the sterile autoclaved meat did not mature at all, but remained for over two weeks in a size corresponding to the second or third instar, and at the end of that time died. This experiment was repeated twice and identical results occurred.

This would seem to indicate that some food factor is destroyed when the meat was autoclaved, that this factor is somehow replaced when this same autoclaved food is contaminated (Glaser, 1924), and that sterilizing at lower temperatures does not destroy this factor at all.

The second lot of maggots, reared by this method was then set aside to be used as a check on the enzymic reactions obtained from the larvae raised on natural contaminated meat as summarized in Table I. The same methods were used for the determination of enzymes as were used previously, except that the maggots were handled under the most aseptic conditions possible. All apparatus used was sterilized. Each maggot was dissected under sterile water, and the instruments used were sterilized in mercuric chloride after each dissection. The portions of the digestive tracts obtained in this manner were then placed in their respective vaccine tubes that had been previously autoclaved, and after the proper chemicals had been added to determine the enzymic reactions, each tube was capped with toluene.

By using these precautions, we were then positive that whatever digestive reactions occurred were due to the presence of enzymes and not to any bacteria that otherwise would have been present.

Hobson (1932a) had previously checked only for the presence of tryptase and pH values in *Lucilia sericata*, and found that tryptase was present in aseptic larvae and that the gut reactions

in them were normal, when he reared the larvae on autoclaved brain mush. Our experiments included the testing for all the enzymes that had been found present or absent in the contaminated larvae, and the aseptic larvae were raised on lean beef. The results obtained are summarized in Table II.

A comparison of the results obtained from those maggots raised in a contaminated medium and those reared aseptically showed that the only difference occurring was a positive test for invertase in the anterior portion of the mid-guts of the contaminated larvae. Furthermore, since the reaction for the

TABLE II.

Digestive Enzymes in Aseptically-reared Larvae of *Phormia regina* Meigen.

Enzyme	Salivary Glands	Crop	Anterior Mid-gut	Middle Mid-gut	Posterior Mid-gut	Hind Gut	Excreta
Amylase	±	—	—	—	—	—	—
Maltase	—	—	—	—	—	—	—
Invertase	—	—	—	—	—	—	—
Lactase	—	—	—	—	—	—	—
Lipase	—	—	±	—	±	±	±
Trypsin	—	—	+	—	+	+	+
Pepsin	—	—	—	—	—	—	—
Erepsin	—	—	+	—	+	±	±
pH	7.0	7.0	6.9	6.6	6.9	7.2	6.8

presence of invertase occurred only once in the three times that the experiment was repeated, it suggests that the hydrolysis of sucrose was not caused by the enzyme but probably by bacteria.

SUMMARY.

In the treatment of osteomyelitis, the role of digestion in blowfly larvae is a significant one, being interrelated with the success of the treatment. A study was made to determine enzymes present, the effect of bacteria on digestion, and the analysis of the excreta.

The only enzymes found present in various portions of the digestive tract were amylase, lipase, trypsin and erepsin.

A method was devised to raise flies from egg to adult aseptically by repeated heatings of the media at low temperatures. It was demonstrated that some food factor is destroyed when the media was autoclaved, that this factor is somehow replaced when this same autoclaved media is recontaminated, and that sterilizing at lower temperatures does not destroy this factor at all.

By this method a check was provided on enzymic determinations in contaminated larvae, and the only significant difference obtained was in the test for invertase; it was found present in the contaminated larvae but not in the larvae reared aseptically, which would seem to indicate that the hydrolysis of sucrose was not caused by the enzyme but probably by bacteria.

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Man and Metals.

This is the story of man's advances as viewed from the standpoint of mining and metals. From the "Age without Metals" to our modern times the author has given us an insight into the various aspects of mining and metals, and how they have tended to shape our civilization. He considers the use of metals and manners of obtaining them from earliest times through the Mediterranean civilizations, the Medieval developments of the Old World, then in the New World starting with the Conquest of Peru and coming down to the mining in Australia, and finally to Cecil Rhodes and Southern Africa. Coal and iron are considered as separate from the rest.

This impressive work should not only be of interest to the mining engineer, the metallurgist, and the geologist, in whose special field it lies; but also to the economist, the student of civilization and development of culture, and to all who are interested in the history of our development.

The work is well written and very readable, sustaining interest throughout its many pages. The author is to be congratulated on the book, the entire make-up of which is pleasing.—W. Berry.

Man and Metals, by T. A. Rickard. Two volumes, 1061 pp., 108 ill. New York, Whittlesey House, (McGraw-Hill Book Co.), 1932. $10.00.

Earth History.

This volume on geology is the first of the Century Earth Science Series and handles Earth History in an entirely new manner. There are four main sections: in the first are considered various physical processes, the time scale and cycles of earth history. The second takes up the physical history of the continents. The third considers the biologic history, and the last, "Man and Earth History."

The arrangement and manner of presentation are new and unusual in what might be called introductory geology. The style is good and the text is not burdened with technical terms or involved explanations. For the general reader it is far ahead of the general run of introductory geologies, but I question its use as a text in introductory geology, as it does not seem to be exactly "teachable." As supplementary reading or general reference it is excellent.

The book is well gotten up and is well handled by the publishers. It should find a ready place in general reading and as a supplementary text.

Willard Berry.

Earth History, by L. C. Snyder. 675 pp. New York, The Century Co., 1932.

THE EFFECT OF HIGH CONCENTRATIONS OF DISSOLVED OXYGEN ON SEVERAL SPECIES OF POND FISHES.

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INTRODUCTION.

The investigation of this problem was undertaken for two reasons: first, because investigations of the oxygen content of pond waters have shown that at times when photosynthesis is proceeding at a rapid rate, the water is supersaturated with dissolved oxygen and second, because of the coming into use of compressed oxygen in aerating fish during transportation. In a paper by Wiebe (1931) it has been shown that in one of the fish ponds the water was saturated 189.50%. Unpublished data obtained at this laboratory by Mr. A. M. MacGavock during the summer of 1931 show that in one of the bass ponds the percentage of saturation of the surface water ranged from 164% at 8:00 A. M. to 304% at 5:00 P. M. The next morning at 7:00 o'clock it was down to 153%. The mass production of O_2 in this case was due to an enormous growth of the blue-green alga, *Anabaena*. In 1928 the water in one of the ponds contained 4.68 p. p. m. of dissolved oxygen at 8:00 A. M. and 15.90 p. p. m. at 3:00 P. M. of the same day, Wiebe (1930).

The effect of high concentration of oxygen on fishes has been studied by Shelford and Allee (1913), by Wells (1913), by Haempel (1928), and by Plehn (Praktikum der Fischkrankheiten). Hubbs (1930) has investigated the effect of nascent oxygen on fish.

METHOD OF PROCEDURE.

The containers used in these experiments were large glass carboys, an iron preserving kettle, and specially constructed fish cans. These containers were so equipped that they could be attached to a tank of compressed oxygen and with an outlet so that water could be displaced by oxygen and samples withdrawn without opening the container. In the glass carboy it was possible to observe the reaction of the fish during the

experiment. This was not possible in the other containers mentioned. The ability of the fish to survive the experiments for shorter or longer periods was used as a criterion.

The experiments are primarily of two types and the results are presented under two sections, A and B. In the first group of experiments the fish were subjected to high concentrations of oxygen under atmospheric pressure with an atmosphere of pure oxygen over the water. In the second group the fish were subjected to pressure of varying degrees. In most of these pressure experiments a layer of pure oxygen was maintained over the surface of the water. The pressure readings were taken in whole and in half pound intervals on a pressure gauge. Then the gauges were calibrated for each scale interval against a mercury monometer. More specific details are given below.

Species of fish used were: largemouth black bass, *Micropterus salmoides*, (Lacepede); smallmouth black bass, *M. dolomieu* (Lacapede); the black crappie, *Pomoxis Sparoides* (Lacepede); the white crappie, *P. annularium* (Rafinesque), the bluegill, *Lepomus incisor* (C. and V.); the golden shiner, *Notemigonus crysoleucas* (Mitchill); the common goldfish, *Carassius auratus* (L.); the orange spotted sunfish, *Lepomus humilus* (Girard); the brook trout, *Salvelinus frontinalis* (Mitchill), and the rainbow trout, *Salmo shasta* (Jordan).

Section A.

Experiments to show, (1) that various species of pond fish can live in water with a stratum of pure oxygen over the water, and (2) that they can stand a sudden transition from water with a low oxygen content to water of a relatively high oxygen content and the reverse.

The experiments were carried out in large glass carboys. The procedure was as follows: The container was completely filled with water before the fish were introduced. After the fish had been put in the container the latter was stoppered tightly and connected to a tank of compressed oxygen. The gas was released close to the bottom of the container. The carboy was also equipped with an exit tube so that some of the water could be displaced by oxygen. In this manner a layer of pure oxygen was established. Preliminary experiments have shown that if the oxygen is introduced near the bottom of the container, it takes only a relatively short time until the

concentration of oxygen becomes fairly uniform throughout the entire mass of water. Samples for oxygen determination were taken close to the bottom. In some experiments, No. 2, for instance, samples were taken at different depths after the fish had been introduced, but no significant difference in the amount of oxygen was discovered. In some instances the oxygen in the experimental container was increased by bubbling oxygen through the water before the fish were introduced. This was done in order that it might be determined if fish can stand a sudden transfer from low to high oxygen tension.

Experiment 1.

Smallmouth Black Bass Fry.

In this experiment 160 smallmouth bass fry ranging in size from 0.5″ to 0.75″ were used. They were taken from pond water having an O_2 content of 10.62 p. p. m., a pH of 9.3, and a temperature of 23.5° C.

Table I.

Shows O_2 in Parts per Million, Temperature in Degrees Centigrade, and pH Value for Experiment Number 1.

Date	Hours	O_2	pH	Temperature	Remarks
5-31-31	2:30 P. M.	20.75	7.3	23.5	Initial condition in carboy when fry were introduced.
5-31-31	5:00 P. M.	28.38	....	....	....
5-31-31	9:45 P. M.	30.71	....	....	....
6- 4-31	5:30 A. M.	30.71	....	....	When the experiment was terminated the CO_2 amounted to 25 p. p. m.
6- 4-31	3:00 P. M.	30.05	7.25	19.5	....

and placed in a carboy whose water had an O_2 content of 20.75 p. p. m., a pH of 7.3, and a temperature of 20.0° C. After the fish had been put in the container the latter was stoppered tightly and some of the water displaced by oxygen, thus creating a layer of pure oxygen over the surface of the water. The experiment was begun at 2:30 P. M., May 31, and was terminated at 3:00 P. M., June 1st. Sufficient fresh water was added at this time to again fill the carboy completely reducing the O_2 to 21.58 p. p. m. Additional data for O_2, etc., are shown in Table I.

No fish were lost during this 24-hour experiment. When the carboy was opened and some water fleas and small shiners put in, the bass fed on them very readily. The fish were kept under

observation in this carboy for a week, the water being aerated with compressed air. No fry died during this period.

At no time did these fish show any signs of uneasiness while they were under an atmosphere of pure oxygen. This together with the fact that they survived so well and took food so readily would seem to show that this treatment had no deleterious effect on these little fish.

Experiment 2.

Largemouth Black Bass Fry.

The procedure in this experiment was the same as in number one. The fish used were 150 largemouth fry 0.5" to 0.75" in length. They were transferred from water having a pH of 7.9, O_2 content of 7.21 p. p. m., and a temperature of 24.0° C., to water having a pH of 7.5, an O_2 content of 27.25 p. p. m., and a temperature of 20.0° C. This experiment was begun at 10:00 A. M., June 4.

At 1:30 P. M. two oxygen samples were taken from this carboy: one at 2" below the surface and another at 8". The former sample had an O_2 content of 31.99 p. p. m., and the latter had 31.44 p. p. m. At 5:20 P. M. two samples were taken at 1.5" and 7.5" respectively. The O_2 content of both samples was 32.75 p. p. m.

At 5:00 P. M. the O_2 1" below the surface was 30.65 p. p. m., and at 7" below the surface it was 29.87 p. p. m. At 9:00 A. M. June 6, the O_2 7" below the surface was 32.75 p. p. m., pH 7.1, free CO_2 15.1 p. p. m., and temperature 19.0° C. The experiment was discontinued at this time. The carboy was refilled with water and the latter aerated with compressed air. The fish were kept under observation until June 11. Up to that time three fry had died.

It would appear from the above that the sudden transfer from an O_2 content of 7.1 p. p. m. to 27.25 p. p. m. did not harm these bass fry and that they could live in water under an atmosphere of pure oxygen.

Experiment 3.

Smallmouth Black Bass Fingerlings.

Procedure same as in number two. Fish used were 75 smallmouth bass having an average length of 1.75". They were transferred from water with an O_2 content of 6.42 p. p. m. to water whose O_2 content was 22.7 p. p. m. The transfer was made at 11:00 A. M. July 10. The temperature in the trough was 21.5° C. and the pH 7.6; the temperature in the carboy was 23.0° C. and the pH 7.2. For additional data on O_2, etc., see Table II.

The experiment was discontinued at 9:00 A. M. July 12, and the fish transferred to water having an O_2 content of 6.0 p. p. m. The fish seemed none the worse for this experiment.

They learned to take artificial food in a few days and acted normally in all respects. No fish were lost during the experiment. The same was true of the control fish. These fish were kept under observation until July 27, i. e., until 17 days after the experiment was begun. During this period only one experimental bass was lost—this one* was dead on July 13. The control fish all survived up to this time.

TABLE II.

Shows O_2 and Free CO_2 in Parts per Million, Temperature in Degrees Centigrade, and pH Value for Experiment Number 3.

Date	Hour	O_2	pH	Temperature	Free CO_2	Remarks
7-10-31	11:00 A. M.	22.7	7.2	23.0	....	Initial conditions
7-10-31	1:00 P. M.	24.69	....	....	....	
7-11-31	8:00 A. M.	20.28	7.0	24.0	35.2	
7-11-31	5:00 P. M.	21.2	7.0	23.5	39.6	
7-12-31	8:00 A. M.	18.2	6.9	23.0	47.5	

The above results would certainly seem to indicate that this size of smallmouth bass could live in water with a superstratum of pure oxygen for a period of 46 hours. Moreover, that they could stand a sudden transition from water having an O_2 content of 6.42 p. p. m. to water having 22.7 p. p. m., and from 18.2 p. p. m. to 6 p. p. m.

EXPERIMENT 4.

Largemouth Black Bass Fingerlings.

This is an exact repetition of number three, only that 50 largemouth bass having an average length of 2.64″ were used instead of smallmouth bass. This experiment was carried on simultaneously with number three and the values for O_2, pH, free CO_2, and temperature are essentially the same as in number three, hence they are omitted. Only the results as far as the fish are concerned are recorded here.

Three bass were lost during this experiment while none of the controls died during the 44-hour period. The remaining fish were kept under observation until July 27. Up to that time 4 more of the experimental bass had died and two of the controls. Although the losses here are greater than in number three, it is still very doubtful that the death of these fish was caused by the high oxygen. The fact that two of the controls also died points the other way. Also the experimental fish were handled more than the controls. This may have had something to do with the greater mortality.

EXPERIMENT 5.

Trout Fingerlings.

The procedure in this experiment is the same as in the preceding experiments. The fish used were 10 rainbow and 10 brook trout that had an average length of about 2.5″ to 3″. The fish were taken from water having an O_2 content of 5.68 p. p. m., and 6.68 p. p. m. They were transferred to water having an O_2 content of 17.1 p. p. m., free CO_2 1.5 p. p. m. The temperature varied from 22.0 to 23° C. during this experiment. Additional observations made during the test period which lasted from 8:00 A. M. July 13 to 8:30 A. M. July 15, are shown in Table III. At this time enough fresh water was added to reduce the O_2 to 10.9 p. p. m. The fish were all in good condition. They were kept under observation until July 23. Only one trout had died up to that time. Hence it seems that to live for 48.5 hours in water under a super-stratum of oxygen produced no ill effect in these fish. (It may be noted here that the temperatures that prevailed during this experiment were unfavorable for these small trout.)

TABLE III.

Shows O_2 in Parts per Million, Temperature in Degrees Centigrade, for Experiment Number 5.

Date	Hour	O_2	Temperature	Free CO_2
7-13-31	4:30 P. M.	23.7	22.0	....
7-14-31	8:30 P. M.	26.2	22.5	....
7-15-31	8:30 P. M.	37.6	22.5	....

From the results of this experiment it would appear that these small trout could stand a sudden and extensive change in the concentration of dissolved oxygen.

EXPERIMENT 6.

Black Crappie and Bluegill Fingerlings.

The experiment was begun at 11:00 A. M. May 23. At that time 12 black crappie 2.5″ to 4″ and 23 bluegill 1.5″ to 2.5″ were transferred to an experimental carboy, and 13 black crappie and 10 bluegill of the same size to a control carboy. In the control the water was aerated with compressed air. In the experimental carboy the O_2 content of the water had been raised by bubbling O_2 through the water before the fish were introduced. After the fish were in the carboy some of the water was displaced with O_2. At the time of the transfer the O_2 in the retaining trough was 3.32 p. p. m., in the experimental carboy the O_2 amounted to 22.41 p. p. m., and in the control 5.48 p. p. m: During the test period the O_2 in the control varied between 4.15 p. p. m. and 7.8 p. p. m. The temperature in both carboys ranged from 17.0° C. to 17.5° C.

Additional oxygen values for the experimental carboy are shown in Table IV. At the end of the experiment the free CO_2 amounted to 7.5 p. p. m. in the experimental carboy. The experiment was terminated at 1:00 P. M. May 25.

At the end of the experiment one of the experimental bluegill was sick and two of the control crappie were dead. Up to May 30, 21.7% of the experimental and 40.0% of the control bluegill had died. At the same time 8.33% of the experimental crappie and 46.1% of the control crappie had died. After that no losses occurred for several days, and the fish were liberated. From these results it would appear that

TABLE IV.

Shows Values for O_2 in Parts per Million for Experiment Number 6.

Date	Hour	O_2	Date	Hour	O_2
5-23-31	1:00 P. M.	25.89	5-24-31	10:00 A. M.	24.88
5-23-31	6:00 P. M.	27.89	5-25-31	8:00 A. M.	21.08
5-23-31	9:45 P. M.	26.72	5-25-31	1:00 P. M.	20.92

these fish had been benefited by the high concentration of oxygen. (It may be well to mention here that these were rescued fish.) The fish that survived the experiment took food readily.

EXPERIMENT 7.

Two-year Old Bluegill.

The procedure in this experiment was the same as in number 5, and it was begun at 4:00 P. M. May 26. In this experiment 10 two-year old bluegill were used. The same number was used for a control. The fish were taken from water having an O_2 content of 2.65 p. p. m. The water in the experimental carboy had an O_2 content of 25.73 p. p. m. at the time the fish were introduced. During the test period the O_2 ranged from 24.03 p. p. m. to 31.87 p. p. m., while the range in the control was from 4.48 p. p. m. to 8.13 p. p. m. The temperature ranged from 18 to 21.5° C. The experiment lasted for 45 hours. At the end of the experiment the fish were transferred to separate compartments of an aquarium. The O_2 in this aquarium amounted to 6.31 p. p. m. Each carboy had one dead fish and one sick fish at the end of the experiment. The dead as well as the sick fish showed definite skin lesions. (The two-year old bluegill had been given a copper sulphate bath a few days before the experiment was begun. They were badly fungused before the treatment.) Two of the experimental and one of

the control fish were dead on May 29; all had definite skin lesions. The fish were kept under observation for two more weeks, but no more losses occurred. The fish were now entirely free from fungus and took food very readily.

Total loss of fish was three experimentals and two controls. Hence it may be concluded that the high oxygen and the atmosphere of pure O_2 over the water had no ill effect on these fish.

Experiment 8.

Largemouth Bass Fingerlings.

Procedure was as in experiment number 7. Fish used were: 6 largemouth bass from 4.25″ to 5.25″ in length. The O_2 content of the water in the experimental carboy had been raised to 40.33 p. p. m. before the fish were introduced. The fish were transferred to this carboy from water having an O_2 content of 5.67 p. p. m. Observations on O_2, and temperature are shown in Table V.

Table V.

Shows O_2 in Parts per Million, and Temperature in Degrees Centigrade for Experiment Number 8. The Per Cent Saturation is Referable to an Atmosphere of Ordinary Air.

Date	Hour	O_2	Temperature	% Saturation
1-27-31	10:10 A. M.	40.33	16.5	410
1-27-31	1:00 P. M.	37.40	16.5	381
1-27-31	4:00 P. M.	35.97	16.5	366
1-28-31	9:00 A. M.	29.43	17.0	302

These fish showed no signs of restlessness when put in the water of high oxygen content. They all survived the experiment and were kept under observation for several days before they were returned to the retaining trough. The sudden transfer from low to high oxygen and the 23-hour stay in water under an atmosphere of pure oxygen had no deleterious effect.

Additional experiments involving more than a hundred largemouth bass, several smallmouth bass, more than 200 golden shiners, several bluegill, at least 50 goldfish, and several crappie all gave essentially the same results.

Section B.

This section deals with the results of experiments designed for the purpose of determining the ability of fish to live under small pressures.

Experiment 9.

Bass, Sunfish, Goldfish and Shiners.

In this experiment an iron preserving kettle was used as a container for the fish. The procedure was essentially the same as in Section A except that no water was displaced and that the oxygen was introduced over the surface of the water instead of being bubbled through the water from the bottom. The result of this modified procedure was a much lower O_2 content of the water, namely, 13.64 p. p. m. at the conclusion of the experiment. The temperature ranged between 17.5 and 18.0° C.

The fish used in this experiment were: 4 largemouth black bass (4.25″ to 5.5″), 2 goldfish (3″ to 3.5″), 1 green sunfish (2.25″), and 8 golden shiners (4″ to 5.5″; this does not include two smaller shiners eaten by the bass in the course of the experiment).

In this experiment a pressure of 7 to 9 lbs. was maintained from 11:30 A. M. to 1:40 P. M. Then from 1:40 P. M. to 11:30 P. M. a pressure from 12 to 13.2 lbs. was maintained. The fish were taken out at 12 o'clock midnight and transferred to water that had an O_2 content of 13.62 p. p. m. No fish except the two shiners consumed by the bass were lost in the experiment. However, one of the larger shiners had several blood stains on its sides. The rest of the fish showed no visible signs of injury. The apparently injured shiner acted perfectly normal, and when these fish were returned to the holding troughs after having been kept under observation for two weeks, was alive and healthy. Since no fish were lost and since the fish acted normally and took food readily, it is concluded that an increase in pressure of from 0.46 to 0.88 atmosphere above normal exerted no deleterious effect on these fish.

Experiment 10.

Bass, Goldfish and Shiners.

This experiment was carried out in two stages. The pressure cooker was again used as a container. In the first part of the experiment the O_2 was bubbled through the water while in the second part it was introduced over the surface of the water. The fish used in part 1 were: 3 largemouth bass (4″ to 5″), 1 smallmouth bass (5″), 3 goldfish (3″ to 3.25″), and 2 shiners (3″ to 3.25″—this does not include several small shiners eaten by the bass in the course of the experiment). The pressure

records for part 1 are shown in Table VI. The initial O_2 was 7.92 p. p. m. at a temperature of 17.5° C. At the conclusion of part 1 the O_2 was 38.5 p. p. m. at a temperature of 16.5° C.

TABLE VI.

Shows Pressure Reading for Part One of Experiment 10 in Pounds.*

Hour	Pressure	Hour	Pressure	Hour	Pressure
10:35 A. M.	0 lbs.	11:20 A. M.	18.6 lbs.	12:40 P. M.	17.6 lbs.
10:55 A. M.	12.1 lbs.	11:25 A. M.	17.1 lbs.	1:05 P. M.	17.6 lbs.
11:00 A. M.	12.1 lbs.	11:30 A. M.	17.6 lbs.	1:10 P. M.	17.6 lbs.
11:04 A. M.	15.4 lbs.	11:35 A. M.	18.6 lbs.	1:15 P. M.	17.6 lbs.
11:05 A. M.	17.6 lbs.	11:40 A. M.	19.6 lbs.	1:20 P. M.	7.85 lbs.
11:10 A. M.	17.6 lbs.	11:45 A. M.	17.6 lbs.	1:25 P. M.	4.30 lbs.
11:15 A. M.	17.6 lbs.	12:05 P. M.	17.6 lbs.	1:30 P. M.	0 lbs.

Part 2 of this experiment was begun at 2:15 P. M. after a 3-inch bluegill had been added. The rest of the fish were the same as in Part 1. The pressure was raised again, but instead of bubbling the O_2 through the water, it was introduced over the surface of the water. The result was that the dissolved oxygen increased only very little during Part 2 of this experiment, namely, from 38.5 p. p. m. to 39.82 p. p. m. The pressure records for Part 2 are given in Table VII.

TABLE VII.

Pressure in Pounds for Part Two of Experiment 10.

Hour	Pressure	Hour	Pressure	Hour	Pressure
2:15 P. M.	0 lbs.	2:45 P. M.	18.6 lbs.	3:45 P. M.	17.6 lbs.
2:17 P. M.	7.17 lbs.	2:55 P. M.	18.6 lbs.	4:00 P. M.	17.6 lbs.
2:30 P. M.	7.85 lbs.	3:05 P. M.	18.6 lbs.	4:20 P. M.	17.6 lbs.
2:40 P. M.	12.10 lbs.	3:20 P. M.	18.6 lbs.	4:40 P. M.	17.6 lbs.

During the interval from 4:40 P. M. to 4:50 P. M. the pressure was reduced from 17.6 lbs. to 0 lbs. The cover was then removed and the fish examined. The fish were on the bottom of the container apparently perfectly at ease.

The fish were left in this container until 8:00 A. M. the next morning, when they were transferred to a holding trough. The fish were all alive and active. Several small shiners had

*Note.—During the intervals between readings the pressure was maintained between the values shown for consecutive readings, i. e., during the interval between 11:20 A. M. and 11:25 A. M. the pressure was never below 17.1 lbs. or above 18.6 lbs.

been eaten by the bass during the experiment. The smallmouth bass had a shiner in its mouth at the time of the transfer. These fish showed no sign of injury whatsoever.

This experiment suggests that these fish could adapt themselves rapidly to an increase in pressure slightly in excess of 2 atmospheres.

In the last two experiments due to the peculiar construction of the iron kettle it was not possible to create a layer of pure oxygen over the water.

Experiment 11.

Bass, Goldfish, Sunfish and Golden Shiners.

In this experiment fish were subjected to a pressure of 9.85 lbs. for 10.5 hours with a layer of pure oxygen over the surface of the water. A glass carboy was used as a container for the 5 largemouth (3.5" to 5.5"), 3 goldfish (3" to 3.5"), 2 bluegill (2.75" to 3"), and 15 golden shiners (2.5" to 5"). For a few minutes during and after the pressure was raised the fish were slightly restless, but they soon became quiet and remained so during the entire test period. (This does not mean motionless, for they moved around freely at all times.)

This experiment was begun at 11:00 A. M. February 13. The following values for O_2 obtained during this experiment at the time indicated: 12:15 P. M., 19.53 p. p. m.; 2:40 P. M., 26.91 p. p. m.; 7:45 P. M., 39.06 p. p. m.; at 9:30 P. M., 42.53 p. p. m. At this time the oxygen tank was disconnected and the pressure allowed to go down to zero in a few minutes. The fish were kept in the carboy until 8:00 A. M. of the next day, at which time they were transferred to an aquarium. The oxygen in the carboy still amounted to 26.26 p. p. m. at the time of transfer. The fish were all in fine condition and apparently had suffered no adverse effect from the conditions of the experiment. On February 28, i. e., fourteen days after the experiment was terminated, all the fish with the exception of the two smallmouth were still alive and healthy. The two smallmouth were dead on February 17, three days after the termination of the experiment. At the time of their death the O_2 in the aquarium was down to 1.08 p. p. m. This was apparently too low for the smallmouth. The other species could survive the low O_2 because they are less timid and come and snap for air at the surface more freely.

NOTE: Some of the bass used in this experiment were still alive in June and July, when they were used in experiments to determine the amount of arsenic in bass.

Experiment 12.

Bass and Trout.

The object of this experiment was to determine if fish considerably smaller than the ones used in experiments 9 to 11 could live under pressure with a super-stratum of pure oxygen. The container used was built of galvanized iron and was air tight. It was also equipped with an inlet for the gas and an outlet for water. The procedure was as follows: The can was completely filled with water before the fish were introduced. After the fish had been put in and the cover tightened down, the can was connected to an oxygen tank and some of the water displaced so that a layer of pure oxygen was formed over the surface of the water. After sufficient water had been displaced the pressure was raised 13.23 lbs. This pressure was attained at 2:30 P. M. July 14, and maintained until 8:30 P. M. of the same day. During the intervals between 8:30 P. M. and 7:30 A. M. the next morning the pressure went down to 11.15 lbs. At 7:30 A. M. the pressure was again raised to 13.23 lbs. by the introduction of additional O_2 and maintained there until 2:45 P. M. July 15. At this time the pressure was reduced to zero rapidly and the fish removed from the water in the can that had an O_2 content of 41.0 p. p. m. to water having an O_2 content of 7.3 p. p. m. The temperature ranged from 21.5° C. to 22.5° C. during the course of this experiment.

Table VIII.

Record of Fish.

Species	Size of Fish	Dead at End of Experiment	Alive at End of Experiment
Largemouth bass	1.25"-2"	3	33
Smallmouth bass	1" -1.4"	0	21
Trout...........	2.5"	2+1 sick	7
Total dead....	....	5+1 sick	Alive 61

These results show that these small fish could stand a pressure of from 11.14 to 13.23 lbs. in excess of one atmosphere for a period of 24 hours. The large-mouth bass had been seined in one of our ponds just before the experiment was begun. While this experiment was in progress four of the largemouth in the retaining trough died, as did also several trout. It must be stated here that the temperatures prevailing during the experiment were beyond the range that is normal for these species of trout (rainbow and brook). From the time the experiment was terminated (July 15th) until August 11, only one individual of each species of bass had died—one large-

mouth was dead on July 30 and one smallmouth on August 6. The trout died as follows: July 16, 1; July 19, 1; July 26, 1; July 28, 3. The remaining trout has disappeared, probably eaten by the bass. All the trout in the retaining pond had likewise died. Hence the death of the trout may not be attributed to the fact that these fish were kept under pressure for 24 hours. Experiment 5, Section A, proves that it was not the high O_2 that proved detrimental.

Experiment 13.

Bass, Goldfish and Sunfish.

Procedure here was the same as in number 12. Fish used were 9 largemouth bass (4″ to 5″), 9 goldfish (2.5″ to 3.5″) and 12 bluegill (2.0″ to 3.0″). These were all tame fish and accustomed to taking artificial food. This experiment was begun at 4:30 P. M. July 14.

A pressure of 13.61 lbs. was attained at 4:45 P. M. At 8:30 P. M. the pressure was down 12.99 lbs. At 7:30 the next morning the pressure was down to 9.85 lbs. The pressure was raised to 12.99 lbs. at that time and retained there until 4:45 P. M. At 2:45 P. M. the O_2 amounted to 41.2 p. p. m. The temperature varied around 22° to 23° C. during this experiment. The fish were taken out of the experimental container at 4:45 P. M. and put in water having an O_2 content of 7.3 p. p. m. When the fish were taken out 3 bluegill were dead. The rest of the fish were apparently in good condition; they immediately began to take minnows and artificial food. On July 16 another bluegill was dead. No additional losses had occurred up to September 8. Apparently then most of these fish were not affected adversely by a pressure ranging from 9.85 to 13.61 lbs. in excess of one atmosphere for 24 hours.

Experiment 14.

Bluegill.

Procedure as in 12 and 13. Fish used were: 30 bluegill from 2″ to 3″ in length. (These fish had recently been rescued from a slough in Illinois.) The fish were placed in the container at 9:45 A. M. July 16 and the pressure raised promptly to 13.23 lbs. This pressure was maintained for 24 hours by keeping the oxygen tank connected with the fish container. Just before the experiment was ended at 9:45 A. M. July 17, the O_2 in the container was 39.2 p. p. m. The temperature ranged from 21° to 22° C. during the course of the experiment. Thirty minutes were used this time to reduce the pressure to zero. When the can was opened, two fish still alive were floating on the surface of the water. The other fish were all at rest on the bottom. All of these fish were then transferred to water having an O_2 content of 10.6 p. p. m. The two sick fish recovered to some extent after the transfer so that at 4:00 P. M. all the fish were swimming around naturally. On July 18, one bluegill was dead, and on the 19th 3 more were dead. Two of these showed skin lesions. The rest of the fish were feeding at that time.

Several bluegill in the retaining trough which served as controls had also died during this time. From July 19 to September 8 no additional fish had died. In view of the fact that two of these dead fish showed definite skin lesions and also since some of the control fish died, the assumption seems warranted that the death of these fish was not caused by the pressure and that healthy bluegill of this size could exist under a pressure of 12.23 lbs. under a super-stratum of pure oxygen for 24 hours. The transfer from water having an O_2 content of 39.2 p. p. m. to water having 10.6 p. p. m. was also withstood by these fish.

Experiment 15.

Crappie and Sunfish.

The procedure in this experiment is the same as in the preceding one. Fish used were: 7 crappie ranging in size from 4″ to 5½″, 3 bluegill (3.25″ to 4.75″), and 1 orange spotted sunfish (2.75″). A pressure of 12.99 lbs. was attained at 1:00 P. M. July 29. At 4:00 P. M. the pressure was still 12.99 lbs., but at 9:00 P. M. it was up to 13.45 lbs. At 7:30 the next morning the pressure was down to 12.4 lbs. This pressure was maintained until 1:00 P. M., when it was reduced to zero fairly rapidly. Before the pressure was released the O_2 amounted to 38.2 p. p. m. When the can was opened, 3 crappie were on their sides but still alive. The fish were taken out at 1:20 P. M. and transferred to water having an O_2 content of 7.1 p. p. m. Two of the sick crappie recovered in a few minutes, but the third one did not recover fully and on August 1 it was dead. The injury to the crappie was probably due to too rapid depression. The crappie that died had an injured air bladder. Four of the crappie, the bluegills, and the orange spotted sunfish showed no ill effects at any time. Up until October 1 only the one crappie had been lost, i. e., one fish out of eleven. Hence it would appear that a pressure of from 12.99 to 13.45 lbs. exerted for 24 hours is not harmful to these larger bluegill and crappie.

DISCUSSION OF RESULTS.

The results given above seem to show that the species of fish used in these experiments can for short periods of time endure relatively high concentrations of dissolved oxygen without producing any immediate ill effects. From the data of some of the experiments it would appear that apparently no ill effects had been produced considering the length of time that the fish were kept under observation. (See especially Experiments 3, 4, 13, 14 and 15.) It is also quite apparent that pressures as high as 13 lbs. can be endured for 24 hours. And pressures as high as 15 to 19 lbs. for a couple of hours. It has not yet been determined whether these fish could endure these higher pressures for longer periods of time.

The phenomenon of air bubbles that was observed by Shelford and Alee (1913) was absent entirely in these experi-

ments. These authors, under the heading "Effect of a great excess of nitrogen and oxygen," record the occurrence of gas bubbles developed in the fins of several species of fish. The water they used contained excess gas to the extent of 1 c. c. per litre of both nitrogen and oxygen. In my experiment the water was supersaturated with oxygen to a very much higher degree. The per cent of saturation has been recorded only in one of our experiments (Number 8), there it reached 410%, i. e., 310 per cent supersaturation. It may, therefore, be assumed that the gas bubbles referred to by these authors were due to the excess nitrogen and not the slight excess of oxygen.

Plehn attributes the occurrence of exophthalmus in trout to the supersaturation of the blood with oxygen. She says, moreover, "dass auch Cypriniden Barsche (Barsche-yellow perch as well as our two species of black bass) wahrscheinlieh alle Fische—durch zuviel Sauerstoff zugrunde gehen. Bei ihnen ist Gasblasenbildung aeusserlich nicht sichtbar—Als auffallendstes Merkmal wird nicht selten eine Truebung der Hornhaut und bei laengerer Dauer auch eine linsen truebung beobachtet." No cases of exophthalmus, opaque lense, or darkening of the cornea were observed in the course of these experiments. She also speaks of the phenomena of irritability and convulsions. These effects were noticed in some of the experiments where larger numbers of the large bass fingerlings were used. In one experiment the details of which have not been included in the text, the bass began to stampede when disturbed. (This sometimes occurs under normal environmental conditions where the fish are confined.) This was on the third day after they had been in a container in which the oxygen was raised suddenly from 5.72 p. p. m. to 20.90 p. p. m., and then permitted to go down gradually. On the third day the O_2 amounted only to 10.41 p. p. m., but the CO_2 amounted to 150 p. p. m., and it was probably the latter that caused the nervousness in the fish. The fish all recovered when transferred to water of a lower O_2 and CO_2 content. In another experiment the fish began to show signs of discomfort on the fourth day of the experiment when the O_2 was down to 6.73 p. p. m. (Temperature, 17.0° C.) The CO_2 was in excess of 200 p. p. m. and was undoubtedly the factor responsible for the great irritability. The assumption that the irritability was not produced by the excess oxygen present at the beginning of the experiment is borne out by the fact that in several

experiments where even higher concentrations of O_2 were used no such irritability was developed.

Haempel (1928) exposed trout (rainbow and brook), carp, (*Cyprinus carpio* L.), Schill (*Lucioperca sandra* Cuv.) and Schleie (*Tinca vulgaris* Cuv.) to high concentrations of oxygen. The highest concentration of O_2 used by him on the trout (adults) was 45.18 p. p. m., the highest used on the carp (adults) 42.61 p. p. m. He noticed one case of opaque lens, but no signs of exophthalmus and of gas bubbles. He gives the results roughly as follows: A marked restlessness, which in the case of the Salmonidae ended in a stampede, marked by an increase in respiration (dyspnae). The young fishes (specially Salmonidae) are seriously injured. They soon turn on their back and pass into a condition of paralysis which he has designated as an "O_2—Narkose." If the exposure to high O_2 is continued the fish die. According to Haempel, the young Salmonidae are more sensitive to the excess of O_2 than the adults. Loosanoff (unpublished data) found that the adult salmon were more sensitive to an excess of oxygen than the fingerlings were. Haempel also calls attention to an excessive production of slime. This was not observed in the experiment reported in this paper. Difference in the rates of respiration were observed.

The change in the rate of respiration for two bass and two bluegill were determined. The results showed that there is a pronounced tendency towards a reduction in the rate of respiration as the concentration of oxygen is increased.

SUMMARY.

(1) Several species of fish have been subjected to higher concentrations of dissolved oxygen when an atmosphere of pure oxygen was maintained over the surface of the water and also with a super-stratum of pure oxygen under pressure.

(2) Several species of fish have been subjected to sudden transfers from low O_2 to high O_2 and the reverse.

(3) The results show (a) that some species of fish tolerate large and sudden changes in the concentration of O_2 in either direction, namely, from 5.67 p. p. m. to 40.33 p. p. m. (Experiment 8), and from 41.2 p. p. m. to 7.3 p. p. m. (Experiment 13); (b) that these fish can live in water containing a large excess of dissolved oxygen with a super-stratum of pure oxygen over the surface (Experiment 9); (c) that several species of fish can stand

a pressure of 10 to 13 lbs. for a period of 24 hours (Experiments 12–15) and pressures from 15 to 19 lbs. for shorter periods (Experiment 10). Longer periods not investigated.

(4) The increase in dissolved oxygen is followed by a slowing down of the respiratory movements.

(5) No instances of exophthalmus, opaqueness of the lens, and of the formation of gas bubbles were observed.

(6) No fish were observed to lose their equilibrium except in a few instances in the pressure experiment where depression occurred too rapidly.

(7) That the exposure to high concentration of dissolved oxygen with a super-stratum of pure oxygen at atmospheric pressures and under small pressure is not harmful is inferred from the small number of fish lost and from the length of time for which a majority of the fish survived the experiment.

(8) The data presented here suggest that they may be applicable to the problem of handling fish during transportation.

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Wiebe, A. H. Notes on the exposure of several species of fish to sudden changes in the hydrogen-ion concentration of the water and to an atmosphere of pure oxygen. Proceedings of the American Fisheries Society, Volume 61. 1931.

Glaciation.

For those interested in glaciation, especially in the New England region, this little book shows the possibilities of what can be compiled and observed by careful, close attention to a small area. The book is worth reading because of the completeness of the information it contains, although I can find no conclusions drawn from all this information. The general get up of the book is good with the exception of the two maps, both of which are crowded on their respective pages, allowing a margin of a scant one-eighth inch. The same may be said of the figures on page 19. I also note that the word schist is misspelled in several places.

WILLARD BERRY.

Alpine Zone of Mt. Washington Range, by Ernst Antevs. viii + 118 pp. Merrill & Weber Co., 1932. To be ordered from Bertha B. Smith, 28 Beacon Ave., Auburn, Me.

A COMPARISON BETWEEN THE SPECTROPHOTOMETRIC AND BIOLOGICAL ASSAY FOR THE VITAMIN A CONTENT OF FISH-LIVER OILS.

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A standardized method of color analysis for Vitamin A (1) by the antimony trichloride reaction has been applied to commercial samples of fish-liver oils. A comparison between the spectrophotometric values and those obtained by biological assay would indicate that there is a considerable error in the antimony trichloride test.

The fish-liver oils which were used in this series of experiments were furnished by the Parke Davis and Company, the Abbott Laboratories, the Eli Lilly Company, the E. R. Squibb and Sons, the Mead Johnson Company and the Upjohn Laboratories. Each of these companies gave feeding tests on their oils so that data could be obtained on the relative values and agreement between the chemical and biological assays. The Parke Davis and Company, through the courtesy of Dr. A. D. Emmett, furnished in addition, colormetric data on their oils as obtained by the Carr Price method, which were made over a period of several years. The data furnished a check on the relation between the colormetric and spectrophotometric methods, as well as the influence of time on these oils. All of the samples used in the tests described in this paper were kept in a refrigerator at 5° C.

The oils have been divided into two sets, (a) those giving with the antimony trichloride reagent an absorption band at 608 mμ (Table I) and (b) those giving an absorption band at 622 mμ (Table II). Ordinary "cod-liver" oil sold in pharmaceutical trade is made from the genus of fish known as the *gadus morrhua*, and generally not exclusively from the cod fish. This group includes the cod, haddock, hake and pallock. All of the oils in Table I were designated as cod-liver oils. They included both domestic and foreign oils. Records on some of the oils would indicate that they had been in storage for some time, while others were quite fresh. There was no apparent relationship between the variations in the color test—biological assay values and the age or source of the oil.

In certain cases where a marked difference was shown between the values obtained from the two methods of assay, both types of assays were repeated and confirmed this difference.

TABLE I.

COMPARISON BETWEEN THE SPECTROPHOTOMETRIC AND BIOLOGICAL ASSAY DATA ON COD-LIVER OILS (BASED ON THE ABSORPTION BAND AT 608 mμ).

Company	Sample No.	Biological Assay	Spectrophotometric Assay (Referred to Sample No. 11 as a Standard)	
I	1	573	590	
	2	500	780	
	3	1000	640	
	4	500	850	
	5	625	800	
II	6	625–500	590	
	7	400–500	690	
	8	450–550	750	
	9	600–666	770	
	10	625+	920	
III	11	1000	1000	
	12	3200	2790	
	13	800	820	
	14	700	670	
	15	600	670	
	16	1900	1060	
	17	800	590	
	18	1350	1730	
	19	1800	1930	
	20	1900	1500	
	21	1000	1190	
IV	22	1000	1170	
	23	1000	850	
	24	4000	5300	
	25	4500	5500	
	26	1300	1300	
				(½ Spectrophotometric Values)
V	27	650	1220*	610*
	28	700	1520	760
	29	500	1100	550
	30	650	1500	750
VI	31	1200	2600	1300
	32	500	1100	550
	33	850	1700	850

*NOTE.—In Groups V and VI it would seem necessary to multiply the spectrophotometric values by a factor of ½ to make the values obtained by this method agree with those obtained by the biological assay.

In Table II are recorded the results obtained from halibut-liver oils. Here, again, there was found to be a wide variation between the two methods of analysis. These oils were for the most part concentrates of the unsaponifiable fraction obtained from the crude oil. In certain cases (samples 34 and 35) the concentrated oils were diluted with sesame oil.

No explanation is offered for the necessity of this factor, of ½, as applied in groups V and VI in Table I, though a

TABLE II.

Comparison Between the Spectrophotometric and Biological Assay Data on Halibut-Liver Oils (Based on the Absorption Band at 622 mμ).

Company	Sample No.	Biological Assay	Spectrophotometric Assay (Referred to the Height of the Extinction Coefficient of No. 11, Table I, as a Standard)
VII	34	500	650
	35	2500	2310
	36	30000	37800
VIII	37	37,500–50,000	64700
	38	37,500–50,000	113800
	39	25,000–37,500	78400
	40	13000	2[illegible]300
IX	41	5000	17000
	42	32500	94800
	43	5000	3800
	44	17500	73200
X	45	62500	84000

justification for its use can be seen in certain groups of oils, where all the members had to be corrected by the same factor. Both the Spectrophotometric and biological assays were repeated on certain of these oils, the results of which only confirmed the previously obtained values. Undoubtedly these variations, since they are so consistent, are due to some cause other than errors of observation, and may be ascribed to some inhibitor, activator or to alteration in the structural nature of the chromophore.

In Table II are presented data on the halibut-liver oils, which gave a band at 622 mμ, or some 14 mμ further towards the red as compared with the color obtained from the cod-liver oils with antimony trichloride. This shift has been reported

by Morton (2). Heilbron, Gillman and Morton (3) suggest that the substance giving the 572 mμ (our 578 mμ) band is an ester and the substance producing the 583 mμ band (which appears at the same time as the 622 mμ band) is an alcohol derived from the former substance by saponification. None of the oils in Table II gave the 608 mμ band as far as could be observed by inspection of the absorption bands, and no amount of dilution with $CHCl_3$ shifted the position of the 622 mμ band. There was a weaker band at 705 mμ which apparently accompanies the 622 mμ band.

The existence of vitamin-containing oils giving markedly different absorption bands (608 mμ and 622 mμ) leads one to postulate the theory that Vitamin A is not a definite chemical compound, but that the physiological effect produced by the so-called "A" vitamin is due to any one of a series of closely related compounds, which must have certain structures in common. As already stated Morton suggests that this difference may be as simple as that between an alcohol and an ester. However, the fact that carotene fades in a manner similar to the fading of fish oils suggests a more complicated mechanism.

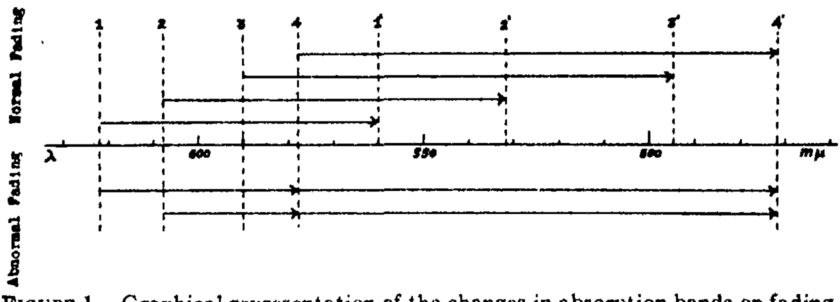

FIGURE 1. Graphical representation of the changes in absorption bands on fading. 1 to 1′ representing the change from 622 mμ to 560 mμ; 2 to 2′ from 608 to 532 mμ; 3 to 3′ from 590 to 495 mμ; and 4 to 4′ from 578 to 472 mμ. The abnormal fading represented below the wave length scale indicates an apparent change from the original chromogen to the 578 form and then fading of the 578 to the final 472 form. This abnormal fading is slight in the case of the 608 mμ chromogen but is the principal reaction in the case of the 622 mμ chromogen.

Following the diagrammatic outline (Figure 1) for the band shifts:

(a) It can be seen that the cod-liver oils producing a band at 608 mμ fade to give a band at 532 mμ (2 to 2′) and those giving a band at 578 mμ fade to 472 mμ (4 to 4′). In case a rather concentrated solution was used so as to give only the 608 mμ and no 578 mμ band, faded bands were observed at both 532 mμ and 472 mμ (2 to 4′). This would indicate that there is a shift from 608 to 578 together with the shift

from 608 to 532 mμ, the latter being more rapid than the former. If the amount of chromogen is unusually large, some 608 changes to 578 which undergoes its normal fading reaction to 472 mμ. In this case just considered, no 578 mμ band appears because the change from 578 to 472 mμ is more rapid than that from 608 to 578 mμ.

(b) The above hypothesis is supported by the fact that if more chromogen is present, both 608 and 578 mμ bands are produced in the blue solution, and both 532 and 472 mμ bands appear in the faded solution. In this case, the 578 mμ band is entirely extinct before the 608 mμ band is extinct, indicating that the amount of chromogen has been reduced to the amount present in case (a) above. These considerations also explain why solutions of oil dilute enough to produce no 578 mμ bands must be used to obtain spectrophotometric values of the 608 mμ bands which are directly proportional to the amount of oil used.

(c) In the case of the halibut-liver oils, a band is produced at 622 mμ, which corresponds to the 608 mμ band produced in ordinary oils. Since the predominate band in the faded solution is at 472 mμ, most of the 622 chromogen must change to the 578 chromogen, which then undergoes its normal fading reaction. Other bands appear in the faded solutions of these oil concentrates at 545, 560, and 580 mμ, only the one at 472 being strong and well-defined.

(d) If the solution of cod-liver oil is made up so that only the 578 mμ (and no 608 mμ) band is produced, the only absorption band in the faded solution is at 472 mμ (4 to 4′).

(e) Carotene gives a band with the $SbCl_3$ reagent at 590 mμ, which fades to give a band at 488 mμ. (Fig. 1, 3 to 3′).

The linear equation ($y = mx + b$) can be used to predict the position of the absorption bands in the faded solutions of these substances.

Let y = band shift expressed in cm^{-1};
x = original position of the band expressed in cm^{-1}; and
m and b are constants to be determined.

Using the band shifts, 578 to 472 mμ and 608 to 532 mμ, the constants m and b can be found, and their values are 1.797 and −27,215 respectively. These values can be substituted in the equation, and the value of "x" determined for each substance, from which the position of the faded band can be calulated:

Original band ("x")	Value of "y"	Faded Band Calculated	Faded Band Observed
(a) Cod-liver oil			
608 mμ	2,348 cm^{-1}	532 mμ	532 mμ
578 mμ	3,879 cm^{-1}	472 mμ	472 mμ
(b) Halibut-liver oil			
622 mμ	1,683 cm^{-1}	563 mμ	560 mμ
(c) Carotene			
590 mμ	5,249 cm^{-1}	495 mμ	488 mμ

The values obtained are all within the limits of experimental accuracy.

It is to be noted that if the "chromogen" in the oil concentrates reacts in what we might term normal fading we would expect to obtain a band at about 560 mμ, where a weak band was observed.

The mechanism of the fading of the 622 mμ band to a band at 560 mμ appears to be perfectly normal and subject to the same explanations that might be applied to the fading of the other solutions. As indicated by the strength of the 560 mμ band as compared with that of the 472 mμ band formed in the same solution only a small part of the chromogen undergoes normal fading, while the principal reaction is the conversion of the chromogen giving a band at 622 mμ into one with a band at 580 mμ which in turn fades to the substance with a band at 472 mμ. Due to the similarity of the bands there is very little doubt but that the 580 mμ band, which was not very well defined, is the same as the 578 mμ band. If, as is apparently the case, the speed of the fading reaction of the chromogen with a band at 578 mμ to one with a band at 472 is equal to, or greater than the speed of the reaction converting the chromogen with a band at 622 mμ to one with a band at 578 mμ, little, if any, indication of the presence of the 578 mμ band would be apparent in the fading solution. It follows then that the chromogen with a band at 622 mμ must either be more stable than the chromogen with a band at 608 mμ, with regard to what we have termed the normal fading (see Fig. 1) or less stable than the chromogen with the 608 mμ band with regard to conversion to the form with a band at 578 mμ, since the principal reaction on the fading of the chromogen with a band at 622 mμ is the formation of a substance with a band at 472 mμ rather than at 560 mμ. Observations on the rate of fading of the halibut-liver oil and the cod-liver oil colors showed that the colors formed by the antimony trichloride reaction with the halibut-liver oils were much more permanent than those colors formed with the cod-liver oils.

Table III is presented to show the agreement over a period of years of the spectrophotometric and colorimetric values. There is very little aging effect over the period indicated.

One of the cod-liver oils was found to be highly flavored with peppermint oil. The spectrophotometric readings on this sample were not proportional to the amount of oil used unless the oil was comparatively dilute, (about a 3% solution in $CHCl_3$). The values obtained by this procedure agreed with

the animal assay. It was subsequently found that peppermint oil in the presence of certain reagents such as sulfuric acid, acetic anhydride, etc., and to a lesser extent with antimony trichloride, gives an absorption band similar to that produced by the fish-liver oils. Perhaps of even more significance is the fact that in the standard color reaction for peppermint oil (5) a blue color is produced with absorption bands at 622, 580, 505 and a weak band at 705 mμ. It was the presence of

TABLE III.

Comparison Between the Colorimetric and Spectrophotometric Assay of Cod-Liver Oils.

Sample No.	Date of Observation			
	Colorimetric			Spectrophotometric
	1928	1928	1931	1931
11	10	9	12	10
12	19	22	27	27.9
13	10	9	10	8.2
14	5.9	4.7	7.5	6.7
15	6.5	6.5	7.5	6.7
16	10	9	10	10.6
17	5.9	5.9	3.9	5.9
18	15	15	16	17.3
19	....	15	16	19.3
20	....	13	13	15.0
21	....	12	12	11.9
27	10	7.5	10	12.2
28	....	....	13	15.2
29	....	9	10	11.0
30	....	12	13	15.0

this latter weak band in the more stable and concentrated color solutions of the peppermint oils that prompted a reexamination of the blue color produced with the halibut-liver oils, with the discovery of a similar band at 705 mμ. (4) In some peppermint oil solutions, particularly those to which mineral acids were added, a band was produced at 605 mμ instead of at 622 mμ. The conditions under which either of these two bands (605 mμ or 622 mμ) might be produced were not determined.

The nature of this blue material in the peppermint oil test is a matter of uncertainty. It has been reported to be azulene, which in turn is said to be produced by the oxidation of cadinene (a member of the sesquiterpene family). An investigation of the green color produced by cadinene, obtained

by distillation of cade oil, showed bands at 605 and 670 mμ, while a sample of German Chamomile oil in chloroform (obtained from Fritschie Bros. who obtained it from Schimmel and Co.) (the source of the material used by Ruczika in his study of azulene (6)) which was bright bule in color gave sharp bands at 608 and 660 mμ. Careful distillation of oil of peppermint produced a fraction, B. P. 60-65° (2-3 mm.) in which practically all of the color forming material is to be found. The blue solutions give a most brilliant red fluorescence.

SUMMARY.

A method for the testing of oils for vitamin A by the use of the $SbCl_3$ reagent has been applied to a number of commercial samples with some agreement between the colorimetric and biological assay values within certain groups of samples.

Differences which did occur were consistent in the samples from any one laboratory or for a a given set of samples.

The nature of the absorption bands produced by $SbCl_3$ on cod-liver oils, halibut-liver oils, and carotene and the resulting faded bands would indicate that several closely allied compounds may be responsible for both the color reactions and the vitamin properties.

Oil of peppermint contains a color-forming compound which has to a rather marked degree the same type of chromogen as is to be found in certain oils known to contain vitamin A.

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Geology.

This book, gotten out in the usual McGraw-Hill style, may well fill a place in the text-book field that has been neglected, i. e., "one-semester beginning course for college students," as the authors say in the preface. The general arrangement and order of presentation would seem to be that which would do very well in such a short course. The text is not over-burdened with needless detail, although some of the words are the less common ones of geologic literature. The illustrations are from many sources; numerous of them are new to textbooks. While I cannot recommend it for longer courses, it should find use in those places where Geology only receives one semester or one quarter of the time of a student—WILLARD BERRY.

Geology, by W. H. Emmons, G. A. Thiel, C. R. Staufer, and I. S. Allison. xii + 514 pp. New York, The McGraw-Hill Book Co., 1932.

A STATISTICAL SURVEY OF OHIO WINTER BIRD LIFE.

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AND
FLOYD B. CHAPMAN,
Ohio State University.

Ornithology was prominent among the biological sciences to first receive any great attention in Ohio. This early developed interest has continued down to the present day and several hundred articles have been published relating to various phases of Ohio bird life. One subject which has been almost entirely neglected until recently, is that which concerns the frequency of occurrence and the relative abundance of Ohio winter birds.

Although ornithologists in all sections of the country have co-operated for 32 years in an annual winter bird census sponsored by Bird Lore Magazine, no attempt has yet been made to assemble the large mass of Ohio data which has accumulated and to apply it to the solution of problems which concern the numbers and distribution of our winter birds.

In the past few years the writers have carefully compiled all the data from Ohio censuses and in the following pages have attempted to present this information in a usable form along with certain interpretations. Little attempt has been made to evaluate the data. They are presented merely for whatever value they may have. Much additional information has also been prepared and placed on file, including for each species the number of individuals observed each year, the average number per census and graphs showing any actual or apparent yearly fluctuations in numbers as shown by the census counts. It is planned to continue this compilation from year to year. These data are available for use by anyone interested in further research on the subject.

All census enumerators have followed a standard plan recommended by Bird Lore since 1900. The usual procedure

is to begin the census field work as early as possible after sunrise, carefully covering an area not to exceed 15 miles in diameter. The observer or party of observers (sometimes several parties working separately), enumerates all birds seen on the trip and tabulates the totals for each species, total number of species and total number of individuals seen. Census co-operators usually spend the full day (seldom less than one-half day) in the field and cover all available area types to get

FIG. 1. Map of Ohio showing census localities.

as nearly as possible a representative picture of the bird life of their section. Records of the temperature, general weather conditions, miles traveled, and various miscellaneous data are sent to Bird Lore. Censuses are taken on any day from December 21 to December 27, and the results are published in the January-February issue of the magazine each year.

Various obvious limitations occur in the use of this compiled information. The data must be properly interpreted and corrected for a number of factors as will be pointed out later in this article. The census observers are, for the most part,

well trained and competent to make counts and correct identifications. The quality of the censuses has steadily increased from year to year as the work became of increasing interest and the co-operators developed a technique for an efficient and more thorough enumeration. The number of species observed per census has also increased. This is believed to be largely due to the increasing interest, greater effort expended,

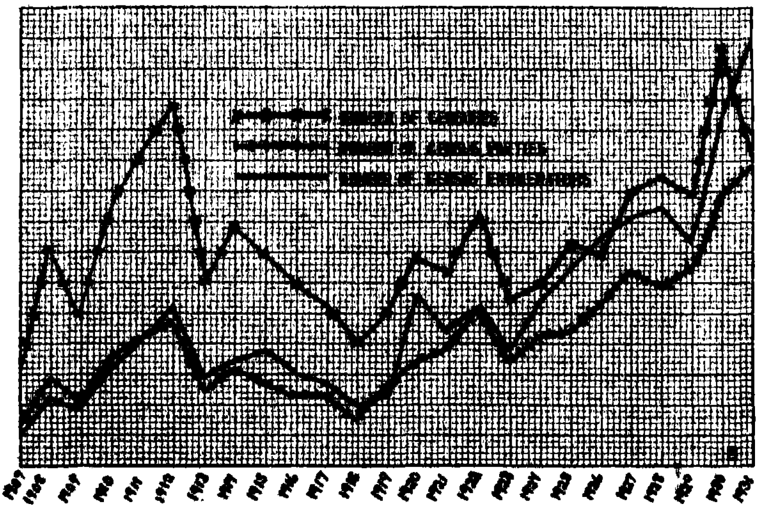

FIG. 2. Graph showing the relative variation from year to year in the number of censuses taken, the number of census parties (sometimes from 2 to 6 census parties combine their records in one census report), and the number of census enumerators. (For actual values of each, see text.) Any graphs made from census data to show the fluctuation in numbers from year to year of a species, should be superimposed upon this graph to aid in proper evaluation of the statistics. This will assist in determining whether certain apparent fluctuations indicate actual changes in numbers.

and the fact that many censuses formerly taken by one or two observers are now secured through the efforts of a group of 5 to 20 enumerators, frequently working in several parties and covering much larger areas than formerly. Exactly half of the censuses by more than two observers have been taken from 1925 to 1931, and half of those taking censuses have participated since 1924.

A summary of the censuses taken to date is shown in Table I, on the following page.

TABLE I.

Year	Number of Censuses Taken	Number of Census Parties	Number of Census Cooperators	Total Species in Whole State	Average Number of Species per Census	Average Number of Species per Census—Period Av'ge
1900	1	1	1	17	14	
1901	2	2	2	17	10.5	
1902	4	4	4	22	13	1900–1906
1903	3	3	5	26	19.6	
1904	3	3	5	27	16.6	15.6
1905	2	2	3	24	16	
1906	2	2	3	27	19.5	
1907	5	5	8	29	12.2	
1908	15	15	18	47	13.8	1907–1911
1909	10	10	15	36	13.6	
1910	17	18	24	40	11.4	12.8
1911	21	21	29	41	13.1	
1912	24	24	38	57	15.9	
1913	12	12	20	48	16.8	1912–1916
1914	16	16	25	47	17.3	
1915	14	14	28	51	14.5	16.1
1916	12	12	22	50	16.0	
1917	11	12	19	50	16.3	
1918	8	8	14	44	14.3	1917–1921
1919	10	13	18	48	16.4	
1920	14	17	41	57	17.7	16.8
1921	13	19	32	60	19.5	
1922	17	26	39	61	23.6	
1923	11	16	27	69	23.1	1922–1926
1924	12	21	38	70	25.6	
1925	15	22	46	73	25.2	24.2
1926	14	26	54	74	23.8	
1927	18	32	58	84	26.3	
1928	19	29	57	72	24.8	1927–1931
1929	18	31	52	71	25.6	
1930	27	45	81	81	21.4	25.7
1931	21	49	98	108	30.8	
Total	392	529	934	....	18.8	

Species per census 1900–1931 = 18.8. Species per census 1922–1931 = 25.0.

199 censuses taken by single observers averaged in number of species.........18.0
108 censuses taken by two observers averaged in number of species.........18.7
30 censuses taken by three observers averaged in number of species.........18.7
18 censuses taken by four observers averaged in number of species.........20.8
10 censuses taken by five observers averaged in number of species.........25.0
6 censuses taken by six observers averaged in number of species.........29.0
3 censuses taken by seven observers averaged in number of species.........37.3
2 censuses taken by eight observers averaged in number of species.........26.0
4 censuses taken by nine observers averaged in number of species.........32.0
2 censuses taken by ten observers averaged in number of species.........43.0
3 censuses taken by eleven observers averaged in number of species.........40.3
3 censuses taken by twelve observers averaged in number of species.........46.3

In addition, single censuses by 13, 15, 16 and 18 observers secured 47, 34, 40 and 50 species respectively.

The following species of Ohio winter birds have been reported in the Christmas Censuses published in Bird Lore from 1901 to 1932, including a total of 392 censuses taken during the 32 years from 1900 to 1931, inclusive. A total of 934 co-operators (about 500 different persons), have taken part in these censuses, from 79 localities in 49 Ohio counties. In all, a total of 133 species and 222,825 individuals have been recorded. Nomenclature and arrangement is that of the American Ornithologists' Union Check List (1931) 4th Edition.

1. Common Loon. *Gavia immer immer* Brunnich.
2. Holboell's Grebe. *Colymbus grisenga holboelli* Reinhardt.
3. Horned Grebe. *Colymbus auritus* Linnaeus.
4. Pied-billed Grebe. *Podilymbus podiceps podiceps* Linnaeus.
5. Double-crested Cormorant. *Phalacrocorax auritus auritus* Lesson.
6. Great Blue Heron. *Ardea herodias herodias* Linnaeus.
7. Black-crowned Night Heron. *Nycticorax nycticorax hoactli* Gmelin.
8. American Bittern. *Botaurus lentiginosus* Montague.
9. Common Canada Goose. *Branta canadensis canadensis* Linnaeus.
10. Lesser Snow Goose. *Chen hyperborea hyperborea* Pallas.
11. Common Mallard. *Anas platyrhynchos platyrhynchos* Linnaeus.
12. Common Black Duck. *Anas rubripestristis* Brewster. (Including the Red-legged Black Duck, *Anas rubripes rubripes* Brewster.)
13. Gadwall. *Chaulelasmus streperus* Linnaeus.
14. Baldpate. *Mareca americana* Gmelin.
15. American Pintail. *Dafila acuta tzitzihoa* Vieillot.
16. Green-winged Teal. *Nettion carolinense* Gmelin.
17. Shoveller. *Spatula clypeata* Linnaeus.
18. Redhead. *Nyroca americana* Eyton.
19. Ring-necked Duck. *Nyroca collaris* Donovan.
20. Canvasback. *Nyroca valisineria* Wilson.
21. Lesser Scaup. *Nyroca affinis* Eyton.
22. American Goldeneye Duck. *Glaucionetta clangula americana* Bonaparte.
23. Bufflehead. *Charitonetta albeola* Linnaeus.
24. Oldsquaw Duck. *Clangula hyemalis* Linnaeus.
25. White-winged Scoter. *Melanitta deglandi* Bonaparte.
26. Ruddy Duck. *Erismatura jamaicensis rubida* Wilson.
27. Hooded Merganser. *Lophodytes cucullatus* Linnaeus.
28. American Merganser. *Mergus merganser americanus* Cassin.
29. Red-breasted Merhanser. *Mergus serrator* Linnaeus.
30. Turkey Vulture. *Cathartes aura septentrionalis* Wied.
31. Black Vulture. *Coragyps atratus atratus* Meyer.
32. Eastern Goshawk. *Astur atricapillus atricapillus* Wilson.
33. Sharp-shinned Hawk. *Accipiter velox* Wilson.
34. Cooper's Hawk. *Accipiter cooperi* Bonaparte.
35. Eastern Red-tailed Hawk. *Buteo borealis* Gmelin.
36. Northern Red-shouldered Hawk. *Buteo lineatus lineatus* Gmelin.
37. American Rough-legged Hawk. *Buteo lagopus s. johannis* Gmelin.
38. Golden Eagle. *Aquila chrysaetos canadensis* Linnaeus.
39. Northern Bald Eagle. *Haliaetus leucocephalus alascanus* Townsend.
40. Marsh Hawk. *Circus hudsonius* Linnaeus.
41. Duck Hawk. *Falco peregrinus anatum* Bonaparte.
42. Eastern Pigeon Hawk. *Falco columbarius columbarius* Linnaeus.
43. Eastern Sparrow Hawk. *Falco sparverius sparverius* Linnaeus.
44. Ruffed Grouse. *Bonasa umbellus umbellus* Linnaeus.
45. Hungarian or European Partridge. *Perdix perdix perdix* Linnaeus.
46. Eastern Bobwhite. *Colinus virginianus virginianus* Linnaeus.
47. Ring-necked Pheasant. *Phasianus colchicus torquatus* Gmelin.
48. American Coot. *Fulica americana americana* Gmelin.

49. Kildeer. *Oxyechus vociferus vociferus* Linnaeus.
50. American Woodcock. *Philohela minor* Gmelin.
51. Wilson's Snipe. *Capella delicata* Ord.
52. Herring Gull. *Larus argentatus smithsonianus* Coues.
53. Ring-billed Gull. *Larus delawarensis* Ord.
54. Franklin's Gull. *Larus pipixcan* Wagler.
55. Bonaparte's Gull. *Larus philadelphia* Ord.
56. Easter Mourning Dove. *Zenaidura macroura carolinensis* Linnaeus.
57. Barn Owl. *Tyto alba pratincola* Bonaparte.
58. Eastern Screech Owl. *Otus asio naevius* Gmelin.
59. Great Horned Owl. *Bubo virginianus virginianus* Gmelin.
60. Snowy Owl. *Nyctea nyctea* Linnaeus.
61. Barred Owl. *Strix varia varia* Barton.
62. Long-eared Owl. *Asio wilsonianus* Lesson.
63. Short-eared Owl. *Asio flammeus flammeus* Pontoppidan.
64. Saw-whet Owl. *Cryptoglaux acadica acadica* Gmelin.
65. Eastern Belted Kingfisher. *Megaceryle alcyon alcyon* Linnaeus.
66. Northern Flicker. *Colaptes auratus luteus* Bangs.
67. Northern Pileated Woodpecker. *Coephloeus pileatus abieticola* Bangs.
68. Red-bellied Woodpecker. *Centurus carolinus* Linnaeus.
69. Red-headed Woodpecker. *Melanerpes erythrocephalus* Linnaeus.
70. Yellow-bellied Sapsucker. *Sphyrapicus varius varius* Linnaeus.
71. Eastern Hairy Woodpecker. *Dryobates villosus villosus* Linnaeus.
72. Northern Downy Woodpecker. *Dryobates pubescens medianus* Swainson.
73. Eastern Phoebe. *Sayornis phoebe* Latham.
74. Northern Horned Lark. *Otocorus alpestris alpestris* Linnaeus.
75. Prairie Horned Lark. *Otocorus alpestris praticola* Henshaw.
76. Northern Blue Jay. *Cyanocitta cristata cristata* Linnaeus.
77. Eastern Crow. *Corvus brachyrhynchos brachyrhynchos* Brehm.
78. Black-capped Chickadee. *Penthestes atricapillus atricapillus* Linnaeus.
79. Carolina Chickadee. *Penthestes carolinensis carolinensis* Audubon.
80. Tufted Titmouse. *Baeolophus bicolor* Linnaeus.
81. White-breasted Nuthatch. *Sitta carolinensis carolinensis* Latham.
82. Red-breasted Nuthatch. *Sitta canadensis* Linnaeus.
83. Brown Creeper. *Certhia familiaris americana* Bonaparte.
84. Eastern Winter Wren. *Nannus hiemalis hiemalis* Vieillot.
85. Bewick's Wren. *Thryomanes bewicki bewicki* Audubon.
86. Carolina Wren. *Thryothorus ludovicianus ludovicianus* Latham.
87. Prairie (Long-billed) Marsh Wren. *Telmatodytes palustris dissaeptus* Bangs.
88. Eastern Mockingbird. *Mimus polyglottos polyglottos* Linnaeus.
89. Brown Thrasher. *Toxostoma rufum* Linnaeus.
90. Eastern Robin. *Turdus migratorius migratorius* Linnaeus.
91. Wood Thrush. *Hylocichla mustelina* Gmelin.
92. Eastern Hermit Thrush. *Hylocichla guttata faxoni* Bangs & Penard.
93. Eastern Bluebird. *Sialia sialis sialis* Linnaeus.
94. Eastern Golden-crowned Kinglet. *Regulus satrapa satrapa* Lichtenstein.
95. Eastern Ruby-crowned Kinglet. *Corthylio calendula calendula* Linnaeus.
96. American Pipit. *Anthus spinoletta rubescens* Tunstall.
97. Bohemian Waxwing. *Bombycilla garrula pallidiceps* Reichnow.
98. Cedar Waxwing. *Bombycilla cedrorum* Vieillot.
99. Northern Shrike. *Lanius borealis borealis* Vieillot.
100. Migrant Shrike. *Lanius ludovicianus migrans* Palmer.
101. Starling. *Sturnus vulgaris vulgaris* Linnaeus.
102. Orange-crowned Warbler. *Vermivora celata* Say.
103. Myrtle Warbler. *Dendroica coronata* Linnaeus.
104. Western Palm Warbler. *Dendroica palmarum palmarum* Gmelin.
105. Eastern Meadowlark. *Sturnella magna magna* Linnaeus.
106. Eastern Red-wing. *Agelaius phoeniceus phoeniceus* Linnaeus.
107. Rusty Blackbird. *Euphagus carolinus* Muller.
108. Bronzed Grackle. *Quiscalus quiscula aeneus* Ridgeway.
109. Eastern Cowbird. *Molothrus ater ater* Boddaert.
110. Eastern Cardinal. *Richmondena cardinalis cardinalis* Linnaeus.
111. Indigo Bunting. *Passerina cyanea* Linnaeus.

112. Eastern Evening Grosbeak. *Hesperiphona vespertina vespertina* Cooper.
113. Eastern Purple Finch. *Carpodacus purpureus purpureus* Gmelin.
114. Canadian Pine Grosbeak. *Pinicola enucleator leucura* Muller.
115. Common Redpoll. *Acanthis linaria linaria* Linnaeus.
116. Northern Pine Siskin. *Spinus pinus pinus* Wilson.
117. Eastern Goldfinch. *Spinus tristis tristis* Linnaeus.
118. Red Crossbill. *Loxia curvirostra pusilla* Gloger.
119. White-winged Crossbill. *Loxia leucoptera* Gmelin.
120. Red-eye Twohee. *Pipilio erythrophthalmus erythrophthalmus* Linnaeus.
121. Eastern Vesper Sparrow. *Pooecles gramineus gramineus* Gmelin.
122. Slate-colored Junco. *Junco hyemalis* Linnaeus.
123. Eastern Tree Sparrow. *Spizella arborea arborea* Wilson.
124. Eastern Chipping Sparrow. *Spizella passerina passerina* Beckstein.
125. Eastern Field Sparrow. *Spizella pusilla pusilla* Wilson.
126. White-crowned Sparrow. *Zonotrichia leucophrys leucophrys* Forster.
127. White-throated Sparrow. *Zonotrichia albicollis* Gmelin.
128. Eastern Fox Sparrow. *Passerella iliaca iliaca* Merrem.
129. Swamp Sparrow. *Melospiza georgiana* Latham.
130. Mississippi Song Sparrow. *Melospiza melodia beata* Bangs.
131. Lapland Longspur. *Calcarius lapponicus lapponicus* Linnaeus.
132. Eastern Snow Bunting. *Plectrophenax nivalis nivalis* Linnaeus.

The following additional species have been reported one or more times by various census enumerators but have been omitted from the above list because there is some question as to their proper identification and occurrence during the Christmas season: Green Heron (*Butorides virescens virescens* Linn.), Broad-winged Hawk (*Buteo platypterus platypterus* Vieillot), Greater Scaup (*Nyroca marila* Linn.), and Pomarine Jaeger (*Stercorarius pomarinus* Temm.). The Chickadees recorded in the censuses were frequently incorrectly listed as to species, or merely listed without determination of species. Records of Chickadees in the enumeration have been divided between the two species occurring in Ohio according to the present known local range of each in winter. Birds listed merely as Horned Larks have been referred to the Northern Horned Lark, though a number of these were probably Prairie Horned Larks and perhaps a few, Hoyt's Horned Larks. A number of unidentified ducks, hawks, owls and other birds have been disregarded in the enumeration.

The total number of accepted species listed on the census reports totals 133. Twenty-nine additional species are known to have occurred in Ohio during the winter season, but have never been observed during a Christmas census, making a total of 162 species, (see Annotated Check-list of Ohio Winter Birds, L. E. Hicks, 1932). These are as follows:

Gannet. *Moris bassana* Linnaeus.
Blue Goose. *Chen caerulescens* Linnaeus.
Red-legged Black Duck. *Anas rubripes rubripes* Brewster.
Greater Scaup. *Nyroca marila* Linnaeus.

Barrow's Golden-eye. *Glaucionetta islandica* Gmelin.
American Eider. *Somateria mollissima dresseri* Sharpe.
King Eider. *Somateria spectabilis* Linnaeus.
Surf Scoter. *Melanitta perspicillata* Linnaeus.
Broad-winged Hawk. *Buteo platypterus platypterus* Vieillot.
Osprey. *Pandion haliaetus carolinensis* Gmelin.
Black Gyrfalcon. *Falco rusticolus obsoletus* Gmelin.
Prairie Chicken. *Tympanuchus cupido americanus* Reichenbach.
Virginia Rail. *Rallus limicola limicola* Vieillot.
Florida Gallinule. *Gallinula chloropus cachinnans* Bangs.
Iceland Gull. *Larus leucopterus* Vieillot.
Great Black-backed Gull. *Larus marinus* Linnaeus.
Atlantic Kittewake. *Rissa tridactyla tridactyla* Linnaeus.
Brunnich's Murre. *Uria lomvia lomvia* Linnaeus.
American Hawk Owl. *Surnia ulula caparoch* Muller.
Great Gray Owl. *Scotiaptex nebulosa nebulosa* Forster.
Arctic Three-toed Woodpecker. *Picoides arcticus* Swainson.
Hoyt's Horned Lark. *Otocoris alpestris hoyti* Bishop.
Pine Warbler. *Dendroica pinus pinus* Wilson.
Northern Yellowthroat. *Geothlypis trichas brachidactyla* Swainson.
English Sparrow. *Passer domesticus domesticus* Linnaeus. (Not enumerated.)
Baltimore Oriole. *Icterus galbula* Linnaeus.
Savannah Sparrow. *Passerculus sandwichensis savanna* Wilson.
Grasshopper Sparrow. *Ammodramus savannarum australis* Maynard.
Smith's Longspur. *Calcarius pictus* Swainson.

The results of the following tabulated data, if properly interpreted, will contribute answers to many important questions concerning Ohio winter bird life, especially those relating to frequency of occurrence and the relative abundance of species present. Individuals actually recorded on any field trip never give an exactly accurate picture of the total bird population present. Corrections must be made for a number of obvious factors. Human tendencies and weaknesses as well as the general habits of the species must be taken into consideration. Certain species will be recorded in numbers not indicative of their true abundance because of:

(1) having loud, clear, frequently uttered notes or songs, making it possible to identify and record the species from a considerable distance, resulting in an actual survey of a larger area for some species than for others.

(2) excessive activity, curiosity and tameness, large size, and conspicuous plumage.

(3) having habits which make the species observable in readily accessible places and against backgrounds which make the bird conspicuous. Example, ground birds vs. arboreal species.

(4) habits of concentration about water, cover, special habitats or where certain foods abound, making it possible to record the species in excess of its true numbers.

(5) activity and presence in accessible areas or locations during hours of the census. For example, according to compiled data, 725

Sparrow Hawks were recorded on 205 or 52% of a total of 392 censuses taken, while only 157 Screech Owls were recorded on 98 or 25% of the censuses and were not checked on the remaining 235. Because of its nocturnal and secretive habits, the latter species is never recorded in proportion to its true numbers and there is good reason to believe that the Screech Owl actually exceeds the Sparrow Hawk in numbers in most Ohio localities during winter.

(6) various historical factors involved. Many species have been decidedly increasing or decreasing in numbers. The figures indicated do not show the present status but the average for a 32-year period. Since the census work began, one species, the Ring-necked Pheasant, has been widely introduced, now occurs in every county and is common to abundant in more than half of the state. Another game bird, the Hungarian Partridge, has been introduced generally and has become common or abundant in about 20 northwestern counties, occurring locally in certain other sections.

The European Starling was first reported from Ohio in January, 1916, from West Lafayette, Coshocton County. The writers have observed the species every year since 1918, making a special study of its first appearances and its subsequent invasion of the state. Records of the species became frequent from 1920 to 1923, and the birds were abundant from 1924 to 1928, spreading westward and southwestward to every county. Starlings were first recorded on a Christmas census in 1920. One report in 1922 gave 14 birds; 2 in 1923, 61; 4 in 1924, 56; 5 in 1925, 177; 12 in 1927, 455; 12 in 1928, 1,218; 13 in 1929, 2,557; 21 in 1930, 2,174; and 27 censuses in 1931 reported 8,570 birds.

Although, of course, not so indicated in the table because of its short occurrence in the state, the Starling is now one of the five commonest, and probably the most common bird in winter, outnumbering on reports of the last five years, all other species except the Crow.

(7) flocking tendencies on the part of certain species. This is a particularly important factor. Flocking and gregarious species always give the impression of being much more abundant than they really are and will be recorded in greater than their actual relative numbers on census lists because of their conspicuousness, ready identification and concentration. This occurs in spite of the fact that most observers tend to greatly underestimate the size of bird flocks, where actual counts cannot be taken.

Of the first ranking 25 species on the basis of individual numbers, 17 are flocking species. Of the first ranking 25 on the basis of number of censuses reporting the bird, only 10 are of the flocking type. In determining the actual status of a species and its true abundance, there is good evidence to show that not only the number of individuals recorded, but also the regularity of occurrence, should be taken into consideration. Where both of these indicators of abundance are used, the list of the first 25 includes 12 gregarious species.

In the table below, column No. 1 ranks the 132 birds reported on censuses by taking into equal consideration the number of individuals reported and the number of times occurring on censuses. Column 2 gives first the number of censuses on which each species has been listed out of a total of 392 taken from 1900 to 1931, and secondly, the number of years in which each species was recorded. Column 3 shows the total number of individuals of each species reported. Column 4 lists the percent of censuses reporting each species, or in other words, the percent of probability of seeing each species on an average winter hike during the Christmas season. This probability, of course, would not apply uniformly to all sections of the state. Column 5 indicates the percent of the total bird population which each species forms. For example, the table indicates that one-fourth of all Ohio winter birds are Crows, nearly one-fifth Tree Sparrows and that one bird of each 32 is a Cardinal. Column 6 ranks each species according to the number of individuals reported and No. 7, according to the number of times checked on census reports.

TABLE II.

Rank of Species Based on Both Numbers and Occurrences	Number Censuses and Number of Years on which Reported	Total Number Individuals Seen	Percent of Censuses Reporting	Percent of Total Bird Population	Ranking According to Individuals	Ranking According to Number Times Reported
1	*2*	*3*	*4*	*5*	*6*	*7*
1. Tree Sparrow	359—32	42,143	91.5	18.90	2	3
2. Cardinal	363—32	7,086	92.6	3.17	6	2
3. Song Sparrow	351—32	8,119	88.0	3.65	5	4
4. Crow	255—28	56,841	64.9	25.40	1	10
5. Slate-colored Junco	322—31	15,236	82.1	6.83	4	7
6. Downy Woodpecker	374—32	4,503	95.4	2.01	11	1
7. Tufted Titmouse	345—32	6,776	88.0	3.04	7	6
8. White-br. Nuthatch	349—32	4,695	89.0	2.10	10	5
9. Bob-white	209—30	6,767	53.3	3.03	8	13
10. Blue Jay	300—32	2,777	76.5	1.24	17	9
11. Black-capped Chickadee	179—32	5,050	45.6	2.37	9	16
12. Starling	98—11	15,782	25.0	7.08	3	26
13. Car. Chickadee	159—30	4,114	40.5	1.84	12	18
14. Hairy Woodpecker	302—31	1,096	77.0	.49	26	8
15. Northern Flicker	210—31	1,260	53.5	.56	24	12
16. Mourning Dove	114—27	2,896	29.1	1.30	16	22
17. Brown Creeper	191—26	1,198	48.7	.54	25	15
18. Goldfinch	156—29	1,593	39.8	.71	21	19
19. Red-bel. Woodpecker	211—31	945	53.8	.42	31	11
20. Robin	102—27	1,910	28.5	.85	20	23
21. Sparrow Hawk	205—30	725	52.3	.33	35	14
22. Carolina Wren	176—29	905	54.9	.40	32	17

TABLE II—(*Continued*)

Rank of Species Based on Both Numbers and Occurrences	Number Censuses and Number of Years on which Reported	Total Number Individuals Seen	Percent of Censuses Reporting	Percent of Total Bird Population	Ranking According to Individuals	Ranking According to Number Times Reported
1	*2*	*3*	*4*	*5*	*6*	*7*
23. Gold.-cr. Kinglet	143—27	1,024	36.4	.45	30	20
24. N. Horned Lark	57—17	2,950	14.5	1.33	15	38
25. Red-h. Woodpecker	98—24	1,028	25.5	.46	29	24
26. Herring Gull	63—18	1,365	16.1	.61	23	35
27. Meadowlark	91—21	886	23.2	.39	33	27
28. Black Duck	40—14	2,139	10.2	.95	18	44
29. Mallard	42—15	1,369	10.7	.61	22	43
30. Lesser Scaup	23—10	3,038	5.8	1.36	14	54
31. Red-tailed Hawk	122—30	208	30.8	.09	48	21
32. Towhee	76—20	512	19.3	.22	38	31
33. Bluebird	75—24	563	19.2	.25	37	32
34. Bonaparte's Gull	21—11	3,622	5.3	1.60	13	58
35. Pr. Horned Lark	40—19	1,032	10.2	.46	28	46
36. Red-winged Blackbird	37—14	1,081	9.4	.48	27	47
37. Winter Wren	85—21	280	21.6	.12	44	30
38. Marsh Hawk	88—16	218	22.4	.09	47	20
39. Screech Owl	98—21	157	25.0	.07	53	25
40. Kingfisher	90—20	162	22.9	.07	51	28
41. Bronzed Grackle	55—22	289	14.0	.13	43	39
42. Cowbird	27—14	739	6.80	.33	34	50
43. Am. Merganser	40—17	410	10.2	.18	40	45
44. R. N. Pheasant	61—18	190	15.8	.08	49	36
45. R. B. Nuthatch	51—26	252	13.0	.11	46	40
46. Snow Bunting	12— 6	2,114	4.0	.94	19	68
47. Cedar Waxwing	28—14	319	7.1	.14	41	49
48. Swamp Sparrow	25—11	304	6.3	.13	42	51
49. Red-should. Hawk	73—24	111	18.6	.04	60	33
50. Cooper's Hawk	64—21	100	16.3	.04	62	34
51. Purple Finch	24—13	254	6.1	.11	45	52
52. Pine Siskin	15—10	619	3.8	.27	36	63
53. Barred Owl	60—26	73	15.3	.03	64	37
54. Ruffed Grouse	51—25	103	13.0	.04	61	41
55. Sharp-shin. Hawk	45—23	63	10.1	.02	67	42
56. Golden-eye	21—12	149	5.3	.06	54	57
57. Rusty Blackbird	15— 9	147	3.8	.06	56	62
58. Gr't. Horned Owl	36—20	45	9.4	.01	71	48
59. Short-eared Owl	18—12	70	4.6	.03	66	59
60. Ring-billed Gull	9— 6	175	2.3	.07	50	78
61. Rough-legged Hawk	24—13	36	6.1	.01	76	53
62. Hooded Merganser	10— 7	147	2.5	.06	55	76
63. Redpoll	10— 7	123	2.5	.05	58	73
64. Killdeer	14— 8	59	3.5	.02	68	65
65. Y. B. Sapsucker	21—16	27	5.3	.01	80	56
66. Mockingbird	23—12	25	5.8	.01	82	55
67. American Coot	7— 4	160	1.8	.07	52	86
68. Barn Owl	17— 9	28	4.3	.01	79	60
69. Pileated Woodpecker	16—10	26	4.1	.01	81	61
70. Canada Goose	7— 5	136	1.8	.06	57	87
71. Field Sparrow	11— 9	41	2.8	.01	74	72
72. Myrtle Warbler	11— 7	37	2.8	.01	75	71
73. W. T. Sparrow	9— 8	53	2.3	.02	69	77
74. Pintail	12— 6	33	3.1	.01	78	69

TABLE II—(*Continued*)

Rank of Species Based on Both Numbers and Occurrences	Number Censuses and Number of Years on which Reported	Total Number Individuals Seen	Percent of Censuses Reporting	Percent of Total Bird Population	Ranking According to Individuals	Ranking According to Number Times Reported
1	*2*	*3*	*4*	*5*	*6*	*7*
75. Hungarian Partridge	7— 6	87	1.8	.03	63	85
76. Turkey Vulture	12—10	26	3.1	.01	83	67
77. Bewick's Wren	15—12	21	3.8	.009	87	64
78. Ruddy Duck	5— 3	122	1.2	.05	59	92
79. Bald Eagle	12—11	24	3.1	.01	84	70
80. Red Crossbill	6— 4	72	1.5	.03	65	90
81. Goshawk	14— 7	15	3.5	.006	91	66
82. Pied-billed Grebe	7— 6	8	1.8	.003	78	80
83. American Pipit	1— 1	500	0.2	.220	39	121
84. Canvasback	7— 5	43	1.8	.01	73	88
85. Red-br. Merganser	5— 3	50	1.2	.02	70	93
86. Horned Grebe	10— 6	16	2.5	.007	90	75
87. Fox Sparrow	8— 6	19	2.0	.008	88	79
88. Northern Shrike	10— 7	13	2.5	.005	95	74
89. Ring-necked Duck	4— 3	35	1.0	.015	77	95
90. Lapland Longspur	7— 6	15	1.8	.006	92	81
91. Baldpate	7— 3	24	1.8	.010	85	89
92. Bufflehead	7— 5	13	1.8	.005	94	83
93. Hermit Thrush	7— 5	7	1.8	.003	99	82
94. Shoveller	4— 2	19	1.0	.008	89	94
95. Black Vulture	3— 3	44	0.7	.018	72	105
96. Great Blue Heron	6— 4	8	1.5	.003	97	91
97. Bohemian Waxwing	3— 3	14	0.7	.006	93	104
98. Redhead Duck	3— 2	7	0.7	.003	101	99
99. Long-eared Owl	4— 4	5	1.0	.002	103	97
100. Green-winged Teal	2— 1	21	0.5	.009	86	114
101. Common Loon	4— 2	4	1.0	.002	106	96
102. Gadwall	3— 2	4	0.7	.002	105	103
103. Palm Warbler	3— 3	4	0.7	.002	107	101
104. Pigeon Hawk	3— 3	3	0.7	.001	112	100
105. Migrant Shrike	3— 3	3	0.7	.001	111	102
106. Wilson's Snipe	3— 3	3	0.7	.001	115	98
107. Old-squaw	2— 2	7	0.5	.003	100	113
108. White-w'g'd Crossbill	1— 1	11	0.2	.004	96	118
109. B. Cr. Night Heron	3— 2	3	0.7	.001	110	106
110. W. Cr. Sparrow	2— 2	4	0.5	.002	109	118
111. Saw-whet Owl	2— 2	3	0.5	.001	114	110
112. Ruby-cr. Kinglet	2— 2	3	0.5	.001	113	111
113. Prairie Marsh Wren	1— 1	4	0.2	.002	108	120
114. Wood Thrush	2— 2	2	0.5	.0009	122	107
115. Snowy Owl	2— 1	2	0.5	.0009	120	109
116. Phoebe	2— 2	2	0.5	.0009	118	112
117. D. C. Cormorant	2— 2	2	0.5	.0009	116	115
118. Evening Grosbeak	1— 1	5	0.2	.002	102	129
119. Woodcock	2— 2	2	0.5	.0009	121	116
120. Holboell's Grebe	1— 1	2	0.2	.0009	117	126
121. Lesser Snow Goose	1— 1	2	0.2	.0009	119	124
122. American Bittern	1— 1	4	0.2	.002	104	132
123. White-winged Scoter	1— 1	1	0.2	.0005	132	117
124. Vesper Sparrow	1— 1	1	0.2	.0005	131	119
125. Orange-cr. Warbler	1— 1	1	0.2	.0005	129	123
126. Pine Grosbeak	1— 1	1	0.2	.0005	130	122

TABLE II—(*Continued*)

Rank of Species Based on Both Numbers and Occurrences	Number Censuses and Number of Years on which Reported	Total Number Individuals Seen	Percent of Censuses Reporting	Percent of Total Bird Population	Ranking According to Individuals	Ranking According to Number Times Reported
1	2	3	4	5	6	7
127. Indigo Bunting........	1— 1	1	0.2	.0005	128	125
128. Golden Eagle..........	1— 1	1	0.2	.0005	127	127
129. Franklin's Gull........	1— 1	1	0.2	.0005	126	128
130. Brown Thrasher.......	1— 1	1	0.2	.0005	123	132
131. Duck Hawk...........	1— 1	1	0.2	.0005	124	131
132. Chipping Sparrow......	1— 1	1	0.2	.0005	124	130

SUMMARY—THIRTY-TWO YEARS, 1900–1931.

Total number of individuals seen............................	222,825
Total number of species....................................	133
Total number of censuses taken..............................	392
Total number of census co-operators.........................	934
Average number species seen on each census, 1900–1931........	18.8
Average number species seen on each census, 1922–1931........	25.0
Average number individuals seen on each census (32 years)....	569
Number of counties (out of 88) in which censuses were taken...	49
Number of localities in which censuses were taken..........	79

The following comparisons should be of interest. The first ranking 25 species are given as follows:

Rank Based on Number of Individuals	Rank Based on Number of Times Reported	Rank Based on Both the Numbers of Individuals and Times Reported
1. Crow	1. Downy Woodpecker	1. Tree Sparrow
2. Tree Sparrow	2. Cardinal	2. Cardinal
3. Starling	3. Tree Sparrow	3. Song Sparrow
4. Junco	4. Song Sparrow	4. Crow
5. Song Sparrow	5. W. B. Nuthatch	5. Junco
6. Cardinal	6. Tufted Titmouse	6. Downy Woodpecker
7. Tufted Titmouse	7. Junco	7. Tufted Titmouse
8. Bob-white	8. Hairy Woodpecker	8. W. B. Nuthatch
9. B. Cap. Chickadee	9. Blue Jay	9. Bob-white
10. W. B. Nuthatch	10. Crow	10. Blue Jay
11. Downy Woodpecker	11. Red-bel. Woodpecker	11. B. Cap. Chickadee
12. Car. Chickadee	12. Northern Flicker	12. Starling
13. Bonaparte's Gull	13. Bob-white	13. Car. Chickadee
14. Lesser Scaup	14. Sparrow Hawk	14. Hairy Woodpecker
15. N. Horned Lark	15. Brown Creeper	15. Northern Flicker
16. Mourning Dove	16. B. Cap. Chickadee	16. Mourning Dove
17. Blue Jay	17. Carolina Wren	17. Brown Creeper
18. Black Duck	18. Car. Chickadee	18. Goldfinch
19. Snow Bunting	19. Goldfinch	19. Red-wgd. Blackbird
20. Robin	20. G. C. Kinglet	20. Robin
21. Goldfinch	21. Red-tailed Hawk	21. Sparrow Hawk
22. Mallard	22. Mourning Dove	22. Carolina Wren
23. Herring Gull	23. Robin	23. G. C. Kinglet
24. Northern Flicker	24. Red-headed Woodpecker	24. N. Horned Lark
25. Brown Creeper	25. Screech Owl	25. Red-headed Woodpecker

Mr. Sidney R. Esten (1931), in compiling the 133 Indiana Christmas Censuses from 28 counties for the years 1900 to 1929, found that 34,299 individuals and 74 species were recorded. The average number of individuals seen on each hike was 258 and of species, 16. The first ranking 25 species (numerical ranking) were as follows: Junco, Tree Sparrow, Crow, Tufted Titmouse, Song Sparrow, Chickadee (both species), Cardinal, Downy Woodpecker, Blue Jay, White-breasted Nuthatch, Mourning Dove, Bob-white, Goldfinch, Bronzed Grackle, Flicker, Prairie Horned Lark, Brown Creeper, Horned Lark, Bluebird, Red-headed Woodpecker, Hairy Woodpecker, Meadowlark, Robin, Carolina Wren, and Lapland Longspur. Indiana censuses indicated increases of Starlings, Crows, Cardinals, Mallards, and Herring Gulls, and decreases of Song Sparrows, Chickadees, Tufted Titmice, Blue Jays, and Downy Woodpeckers.

In Ohio, a number of factors make it difficult to conclude definitely as to any pronounced increases or decreases of the various bird species enumerated and this aspect would be too lengthy to discuss in the present paper. It is planned to continue to collect abundance data on each species from various sources, and to publish the same after a longer period of comparative studies.

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Hydrodynamics.

The latest edition of this well-known work includes new material on the theory of the tides, on various problems of aeronautics, and on other recent developments in this field. No change in the general plan or arrangement is in evidence, but a thorough revision of the older material has been made.

Hydrodynamics, by Sir Horace Lamb. Sixth edition, revised. XV + 738 pp. New York, The Macmillan Co., 1932.

Sedimentation.

The first edition of this important work was exhausted shortly after it appeared and now this new edition is available. The new edition is in truth a new edition. One part has not been rewritten because that part was written by Dr. W. D. Matthew, now deceased, with no one to take his place. The rest of the book has been so expanded as to be an entirely new book. Those who have a first edition will need the new edition. Those who are interested in sediments from almost any angle will need this new edition. It will be of use to the student of sediments, the paleontologist, the economic geologist, and the student of "hard rocks." One can get some idea of the increase of material in the new edition by a few comparisons. The old edition had 696 pages, 61 figures and 55 tables; the new edition has 960 pages, 121 figures, and 91 tables. The old edition referred to 697 authors, while the new edition refers to 819. It is a piece of work that Prof. Twenhofel is to be complimented upon. The publishers also deserve credit for the pleasing make-up of the new book. The use of calendered paper throughout and the clearness of the printing make it very pleasing.—WILLARD BERRY.

Treatise on Sedimentation (second edition), by W. H. Twenhofel. 960 pp., 121 ill. Baltimore, the Williams and Wilkins Co., 1932. $8.00.

THE OHIO JOURNAL OF SCIENCE

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NEW SPECIES AND VARIETIES OF FRESHWATER ALGAE FROM CHINA.*

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During the years 1930–1932 through the generous cooperation of scientific men and friends in China and America, the writer received a rather continuous supply of Chinese freshwater algae collected at different localities and seasons. Among the algae of the eight hundred collections examined were four new species and two new varieties. The following is a description of these forms, the time and place of collection, and notes on their habitats. Both Latin and English diagnoses are given:

Scytonema crispum (Ag.) Born. var. **minus** var. nov.
(Plate I, Fig. 4.)

Strato caespitoso, intricato, viridi-fuscescente vel olivaceo; filis 10–15μ crassis, 0.51–1 centim. longis, crispis; pseudoramis conformibus; vaginis firmis, membranaceis, hyalinis; trichomatibus 7–10μ crassis, cellulis 3.0–4.0μ longioribus; heterocystis 8–10μ latis, 6–10μ longioribus; depressis vel quadratis, modo numerosis.

Plant mass caespitose, entangled, woolly, green to brown; filaments 10–15μ in diameter, about 0.5–1 cm. in length, curled, branched; sheath firm, membranaceous, colorless; trichomes 7–10μ in diameter, cells 3.0–4.0μ in length; heterocysts 8–10 × 6–10μ, depressed or quadrate, numerous.

Similar to the species proper but distinguished by smaller dimensions of the trichomes.

"On rocks with dripping water" (Wang), Nanking, China, April 16, 1930. Type, Mr. Y. C. Wang's collection, No. 76 and 77, in the Herbarium of National Tsing Hua University, Peiping, China.

*Papers from the Department of Botany, the Ohio State University, No. 304.

Oedogonium sinense sp. nov.
(Plate I, Fig. 1.)

Oedogonium dioicum nannandrium, idioandrosporum (?); oogoniis singulis, ovoideis vel globoso-ellipsoideis, poro supramediano apertis; oosporis subglobosis vel oviformis, oogonia fere complentibus, laevi, fuscescentibus; cellulis vegetativis leviter capitellatis; nannandribus in cellulis suffultoriis curvatis; cellulis vegetativis 29–44μ latis, 128–170μ longioribus; cellulis suffultoriis 64μ latis, 182μ longioribus; stipite nannandribus 23μ latis, 82μ longioribus; antheridio exteriore, 2-cellulari, 12–14μ latis, 15–18μ longioribus.

Dioecious, nannandrous, idioandrosporous (?); oogonium 1, ovoid or globose-ellipsoid, poriferous, pore supramedian; oospore subspherical or oviform, almost filling the oogonium; spore wall smooth, yellow-brown; vegetative cells slightly or not capitellate; dwarf male curved, on suffultory cell; vegetative cells 29–44 $\times$ 128–170μ; suffultory cell 64 $\times$ 182μ; dwarf male stipe 23 $\times$ 82μ; antheridium exterior, 2-celled, 12–14 $\times$ 15–18μ.

Distinguished from *Oedogonium nebraskense* Ohashi by its larger dimensions and smooth oospore walls.

In association with other algae in Hsuan Wu Lake, Nanking, China, April 20, 1930. Type, Mr. Y. C. Wang's collection, No. 125, in the Herbarium of National Tsing Hua University, Peiping, China.

Mougeotia sinensis sp. nov.
(Plate I, Figs. 2–3.)

Cellulis vegetativis 15–22μ latis, 100–132μ longioribus; cellulis conjugatio leviter geniculatis; sporangia inter 2 cellulis sitis; chromatophoro elongato cum pyrenoidibus 4–6; zygosporis ovoideis vel globosis, 25–31μ latis, 29–31μ longioribus, formatis canali copulationis; mesosporio angulari-reticulato, fuscescentibus.

Vegetative cells 15–22 $\times$ 100–132μ; conjugating cells slightly geniculate; sporangia adjoined by 2 cells; chromatophore with 4–6 pyrenoids in a single row; zygospores ovoid to globose, 25–31 $\times$ 29–31μ, formed in the conjugating tube; median walls angularly reticulate, yellow-brown.

Among the species of Mougeotia in which the sporangia are joined by two cells, *Mougeotia sinensis* is the only one with angularly reticulate zygospores.

Intermixed with *Zygnema synadelphum* Skuja and other algae, Tinghai, China, Spring, 1930. Type, Prof. C. C. Wang's collection, No. 501, in the Herbarium of National Central University, Nanking, China.

Spirogyra wangi sp. nov.
(Plate I, Figs. 7–8.)

Cellulis vegetativis 30–32μ latis, 150–350μ longioribus, dissepimenta replicata; 2–3 chromatophoris anfractibus 1.5–4.5; cellulis fructiferis ad 72μ inflatis; zygosporis ellipsoideis, 60–64μ latis, 112–124μ longioribus; mesosporio laevi.

Vegetative cells 30–32 × 150–350μ, with replicate end walls; 2–3 chromatophores making 1.5–4.5 turns; fertile cells inflated to 72μ; zygospores ellipsoid, 60–64 × 112–124μ; median wall smooth.

Characterized by the inflated fertile cells, larger zygospores and number of chromatophores.

Growing with other filamentous algae, Hangchow, China, Spring, 1930. Type, Prof. C. C. Wang's collection, No. 40, in the Herbarium of National Central University, Nanking, China.

Spirogyra sinensis sp. nov.
(Plate I, Figs. 5–6.)

Cellulis vegetativis 22–24μ latis, 115–136μ longioribus; dissepimentis planis; 2–4 chromatophoris, anfractibus 2.5–4.5; cellulis fructiferis medio valde inflatis fere 50μ; zygosporis lenticularis, diam. 38–45μ; mesosporio laevi.

Vegetative cells 22–24 × 115–136μ; end walls plane; 2–4 chromatophores making 2.5–4.5 turns; fertile cells inflated toward the middle to about 50μ; zygospores lenticular, 38–45μ in diameter; median walls smooth.

This species is distinguished from *Spirogyra pellucida* (Hass.) Kutz. and the variety *minor* Tiffany by the smaller vegetative cells and fewer number of chromatophores in some of the cells, and by the very thick zygospore wall.

Hsuan Wu Lake, Nanking, China, April 20, 1930. Type, Mr. Y. C. Wang's collection, No. 125, in the Herbarium of National Tsing Hua University, Peiping, China.

Zygnema collinsianum Transeau var. **ornatum** var. nov.
(Plate I, Figs. 9–10.)

Cellulis vegetativis 28–32μ latis, 34–96μ longioribus; cellulis fructiferis uno latere (in quo conjugatio sequiter) fere inflatis; zygosporis globosis vel ovoideis, 28–32μ latis, 32–35μ longioribus, maturitate caeruleis, mesosporio scrobiculis magnis.

Vegetative cells 28–32 × 34–96μ; fertile cells inflated slightly on the conjugating side; zygospores, in one of the gametangia, globose to ovoid, 28–32 × 32–35μ, median walls pitted, blue; pits of median walls about 6μ in diameter.

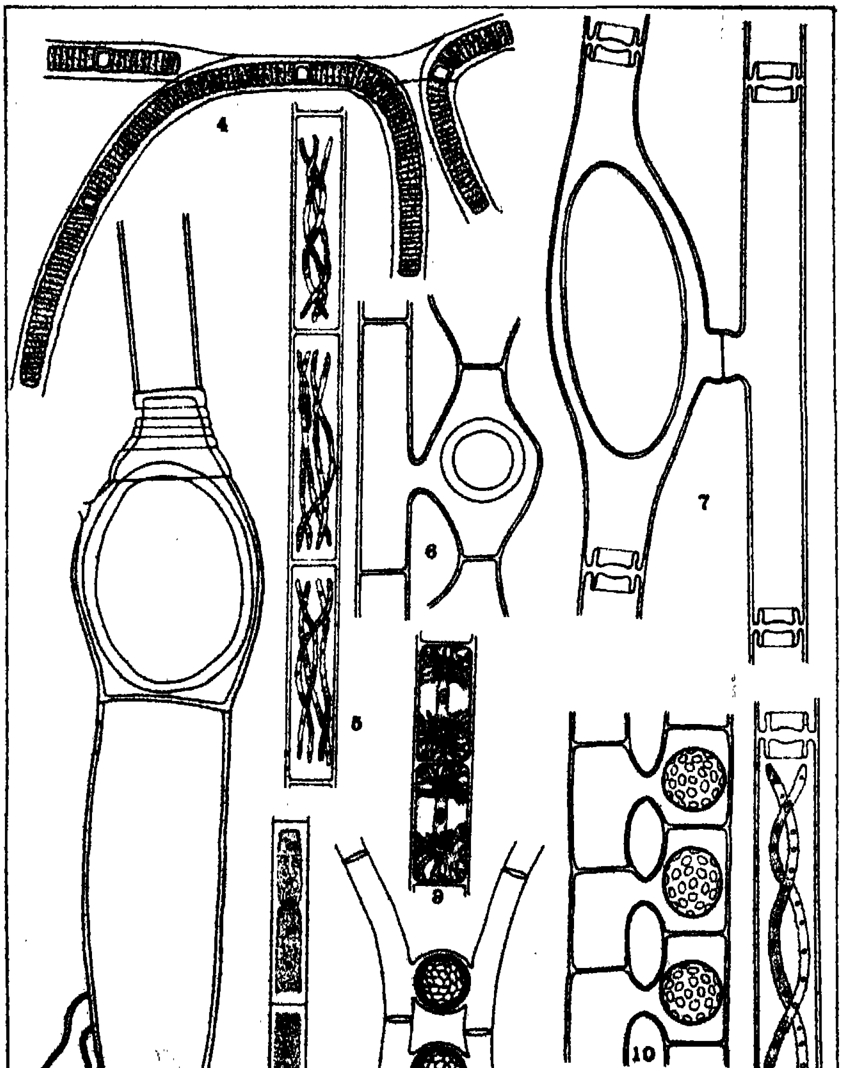
Distinguished from the type by the larger dimensions of the vegetative cells; otherwise similar.

"Floating in mass in a pool, and in the fields just in front of Nanputo Temple" (Tseng), Amoy, China, April 16, 1931. Type, Mr. C. K. Tseng's collections FB Nos. 1 and 2, in the Herbarium of the University of Amoy, Amoy, China. Subsequently found in U. S. A. (Alabama, Mississippi, and Oklahoma).

The writer wishes to thank Professors Lewis H. Tiffany and Edgar N. Transeau, of the Department of Botany, the Ohio State University, for their helpful suggestions, kind criticisms, and the checking of determinations. For the generous supply of their collections of algae from different parts of China, the writer is indebted to Professor Josephine E. Tilden, University of Minnesota; Mr. Y. C. Wang, National Tsing Hua University; Professor C. C. Wang, National Central University; Professor H. H. Chung and Mr. C. K. Tseng, University of Amoy; and Professor J. W. Dyson, Soochow University.

EXPLANATION OF PLATE.

Fig. 1. *Oedogonium sinense*, sp. nov.
Figs. 2–3. *Mougeotia sinensis* sp. nov.
Fig. 4. *Scytonema crispum* (Ag.) Born. var. *minus* var. nov.
Figs. 5–6. *Spirogyra sinensis* sp. nov.
Figs. 7–8. *Spirogyra wangi* sp. nov.
Figs. 9–10. *Zygnema collinsianum* Transeau var. *ornatum* var. nov.



THE GENUS ZYGOGONIUM.

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Taking *Zygogonium ericetorum* (Kütz.) de Bary as the type species of the genus there are three outstanding characteristics that clearly separate these forms from the species of *Zygnema*. In the first place the chromatophores are a pair of rounded plate-like, or irregular polsterform bodies, each with a central more or less prominent pyrenoid. When grown under conditions of poor nutrition the chromatophores may be poorly defined, and when gorged with starch grains and oil droplets the outline may become almost completely obscured. These facts account for the many conflicting descriptions of the chromatophores in the literature discussed by West and Starkey, 1915, and by Skuja, 1932. Certainly in the many collections I have seen from various parts of the world, the chromatophores were never stellate or globose with radial projections as in *Zygnema*. Most authors following Palla are agreed that the chromatophores afford one of the fundamental bases of separating the genera of the *Zygnemales*.

In the second place, a sporangium wall is formed which cuts off the gametangia before the formation of the spore wall. De Bary, 1858, and Hodgetts, 1918, have described the conjugation of this species as proceeding by formation of secondary gametangia which subsequently fuse and form the zygote. It is quite probable that such fusions do take place. However, a not improbable interpretation of their figures and observations is that these are arrested and encysted stages in conjugation, comparable to those sometimes found in other Zygnemales subjected to sudden changes in water content and temperature. Furthermore, *Z. ericetorum* has an unusual tendency to form aplanospores, akinetes, azygospores, or "cysts," as has been remarked by West, Fritsch, and many others. It seems probable that W. & G. S. West (1894) gave the first correct account of the conjugation of *Z. ericetorum* when growing under favorable conditions in their description of "Zygnema pachydermum." In material collected near Longwood, Florida, in a drainage ditch I found not only the encysted stages described

by de Bary and by Hodgetts, but also conjugation without the formation of secondary gametangia, as shown on the accompanying figures.

The third characteristic of *Zygogonium* is that there is a cytoplasmic residue left in the gametangia, just as in the genus Mougeotia. This is very marked in *Z. ericetorum*, and also takes place when aplanospores are formed from vegetative cells. In *Zygnema* such residues have not been observed either in conjugation or in aplanospore formation.

Skuja (1932) has shown that *Pleurodiscus* Lagerheim is merely an extreme form of *Z. ericetorum* in which the two chromatophores are disc or saucer-shaped. West has examined the original specimens of *Zygogonium didymium* Rabenh. (Alg. Exsic. No. 182) and found them to be identical with *Z. ericetorum*.

As the genus *Zygogonium* is here defined there is no basis for separating *Pyxispora* W. & G. S. West (1897). This genus was largely postulated on the basis of a prominent equatorial suture in the sporangium wall. The Florida material of *Z. ericetorum* also shows a median suture on some of the sporangia and the spores are set free by the splitting of the sporangium wall along this line.

The plant rather inadequately described by Schmidle in 1897 as "Zygnema Heydrichii" should evidently be classified in this genus. This collection showed only lateral conjugation with the zygote formed in the greatly enlarged tube, which is cut off from the gametangia by cross walls and thus forms a distinct sporangium. Schmidle's figures suggest that this sporangium also splits by a median suture.

Recently Iyengar has described a species from India that is distinguished by the peculiar and regularly lateral position of the aplanospores.

Finally two species described as Zygnemas which have been found producing only aplanospores seem to be better classified in this genus.

Following are the diagnoses of the genus and six species.

ZYGOGONIUM (Kütz.) de Bary.

Filamentous algae with cylindrical cells containing two axillary disc-, or polsterform chromatophores with rounded, or irregular, margins, each with a central pyrenoid; connected by a cytoplasmic isthmus to which the nucleus is attached laterally. Filaments usually unbranched,

but sometimes with lateral branches of several, or many, cells. Cell walls thin, or lamellate and greatly thickened, often yellowish or brownish in color, cell sap sometimes purple.

Reproduction by akinetes, aplanospores and by zygotes. Akinetes formed by pronounced thickening of cell walls. Aplanospores formed by the contraction of a part of the cell contents and the formation of a new globose or ovoid spore wall within the vegetative cell wall, leaving a more or less conspicuous mass of cytoplasmic residue outside the spore wall. Zygotes produced by the scalariform, or lateral conjugation of isogamous gametes, which are formed from only a part of the cell contents. Encysted gametes have been interpreted as secondary gametangia, but are not necessarily formed in aquatic habitats. Zygotes enclosed in a definite sporangium, which dehisces by an equatorial suture. Spore wall smooth or scrobiculate.

1. **Zygogonium ericetorum** Kützing, 1843.

(Plate I, Figs. 1–12; Plate II, Figs. 33–35.)

Phycologia generalis, p. 446; A. de Bary, Untersuchungen uber die Familie der Conjugaten. 1885; West and Starkey, Cytology and Life History of *Zygnema ericetorum*, New Phytologist, 14: 194. 1915; Hodgetts, Conj. of *Zygogonium ericetorum*, New Phytologist, 17: 238, 1918; Skuja, Le genre *Pleurodiscus*, Rev. algolog. 6: 137. Includes *Z. didymum* Rab., *Z. agardhii* Rab. and *Pleurodiscus purpureus* (Wolle) Lagerheim and *Zygnema pachydermum* W. & G. S. West.

A highly variable terrestrial or submerged form with unbranched or branched filaments. Vegetative cells vary from 12–33μ in diameter and from 10 to 100μ in length. Chromatophores two, axillary, disc- or polsterform or indefinite, each with a central pyrenoid, zygospores develop in a definite sporangium, formed by the conjugating tube and cut off from the adjoining gametangia. Zygospores thick walled, smooth, ovoid or ellipsoid, 15–26μ × 20–36μ. Aplanospores globose or ovoid, occupying only a part of the cell, 15–20μ × 15–40μ, wall smooth.

In terrestrial forms the cell sap is frequently purple, the cells somewhat smaller, and the walls thick, lamellate, colored yellow or brown. Widely distributed in bogs, acid pools, and on wet acid soils. Reported from all of the continents. In America known to occur throughout the coastal plain from New Brunswick to Mississippi and in Ohio, Michigan and Southern Ontario.

2. **Zygogonium mirabile** (W. & G. S. West) Comb. nov.

(Plate II, Figs. 18–20.)

Pyxispora mirabilis W. & G. S. West, Welwitsch's African Freshwater Algae, Jour. Bot. 35: 1897; *Zygnema mirabile* (W. & G. S. W.) Czurda, 1932.

Vegetative cells 12–13.5μ × 18–50μ with two rather indistinct chromatophores, each with a central pyrenoid. Only a part of the contents of the vegetative cells enters into the formation of the

gametes. Zygospores formed in the enlarged conjugating tubes, which are walled off from the original cells. Sporangium ovoid with prominent equatorial suture. Spores filling the sporangium smooth walled, but possibly not mature in the one known collection, 13.5–17μ × 19–32μ.

Collected by Welwitsch, Huilla, Portuguese West Africa, April, 1860.

3. **Zygogonium heydrichii** (Schmidle) Comb. nov.

(Plate II, Figs. 21–25.)

Zygnema heydrichii Schmidle, Zur Entwickelung einiger Zygnema und Calothrix. Flora 83: 167. Pl. V, Figs. 5–7, 10–11. 1897.

Vegetative cells 20μ × 25–66μ, with two chromatophores, not stellate, in each cell. Conjugation lateral by tubes arising from adjoining cells, forming a sporangium cut off from the original cells. Spores globose, ovoid or heart-shaped, 24–28μ × 32μ, median wall yellow, scrobiculate.

Collected by Lauterbach at Sidney, Australia.

4. **Zygogonium capense** (Hodgetts) Comb. nov.

(Plate II, Figs. 26–28.)

Hodgetts, W. J. Some Freshwater Algae from Stellenbosch, Cape of Good Hope. Trans. Roy. Soc. South Africa, 13: 66. 1925. (*Zignema capense.*)

Vegetative cells 16–20μ, 1.3–3 diameters long, conjugation unknown, aplanospores globose formed at the ends of the cells, 19–26μ in diameter, median wall brown, scrobiculate.

Evidently closely related to *Z. heydrichii*. The tendency to form aplanospores at the ends of vegetative cells is also characteristic of many collections of *Z. ericetorum*.

On damp earth, Stellenbosch, South Africa.

5. **Zygogonium hansgirgi** (Schmidle) Comb. nov.

(Plate II, Figs. 29–32.)

Schmidle, W. Ueber einige von Prof. Hansgirg in Ostindien gesammelte Suesswasseralgen. Hedwigia 39: 160. 1900. (*Zignema hansgirgi.*)

Filament short, vegetative cells irregular 8–12μ, 3–5 diameters long, conjugation unknown; aplanospores variable, ovoid, about the same diameter as the cells; median wall brown, with small angular protuberances (verrucose).

Igatpuri, India, 1895.

6. **Zygogonium talguppense** Iyengar, 1932.

(Plate II, Figs. 36-37.)

Iyengar, O.-P. Studies on Indian Zygenemales, Rev. Algologique **6: 263-274.** 1932.

Filaments forming a thick felt on soil, increasing in width upwards, often branching below, lower cells of the filament 12-16μ $\times$ 30-60μ, the upper 17-20μ $\times$ 30-90μ. Aplanospores ("azygospores") developed in a lateral swelling and cut off from the parent-cell by a curved wall, ellipsoid to subglobose 12-26μ $\times$ 13-34μ, median wall smooth; zygospores unknown.

On moist soil in a plantation of Areca palms, Talguppa, Mysore, India.

EXPLANATION OF PLATES.

Plate I.

(Figs. 1-12. *Zygogonium ericetorum* from a drainage ditch at Longwood, Florida.)

Fig. 1. Zygospores of various forms: (a) sporangium wall showing equatorial suture; (b) ruptured sporangium from which the spore has escaped.

Fig. 2. Conjugation without formation of secondary gametangia, also aplanospores adjoined by cytoplasmic residue.

Fig. 3. Zygospores and conjugating gametes (a) and encysted gametes at (b).

Fig. 4. Zygospores (a) and at (b) aplanospore that has germinated and formed a secondary aplanospore inside the original vegetative cell.

Fig. 5. Encysted gametes which may perhaps conjugate later.

Fig. 6. Germinating aplanospores.

Fig. 7. Filament showing rhizoidal branches.

Fig. 8. Zygospores, parthenospore and several aplanospores.

Fig. 9. Cells showing lamellate wall and distinct H-pieces formed between the cells.

Fig. 10. Thick-walled short cells.

Fig. 11. Conjugation of gametes with prominent pectic ring at (a), and at (b) sporangium wall formed on one side and not on the other.

Fig. 12. Zygospore.

Plate II.

Figs. 13-15. *Zygogonium ericetorum* (formerly described as *Pleurodiscus purpureus* Lagerheim) after Skuja, 1932.

Fig. 16. *Z. ericetorum*, aplanospores after West & Starkey, 1915.

Fig. 17. *Z. ericetorum*, actively growing cell after Czurda, 1931.

Figs. 18-20. *Zygogonium mirabile* showing sporangia and spores after G. S. West.

Figs. 21-25. *Zygogonium heydrichii* showing lateral conjugation after Schmidle.

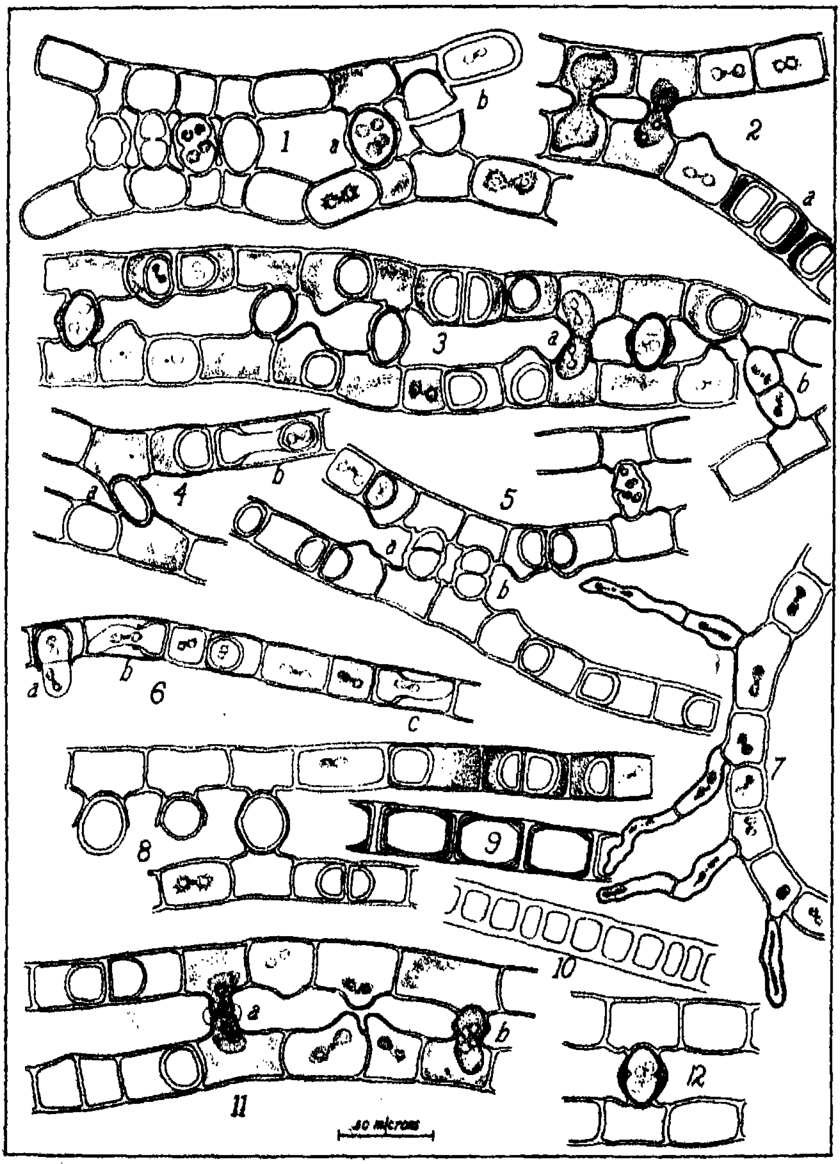
Figs. 26-28. *Zygogonium capense* showing aplanospores, after Hodgetts, 1925

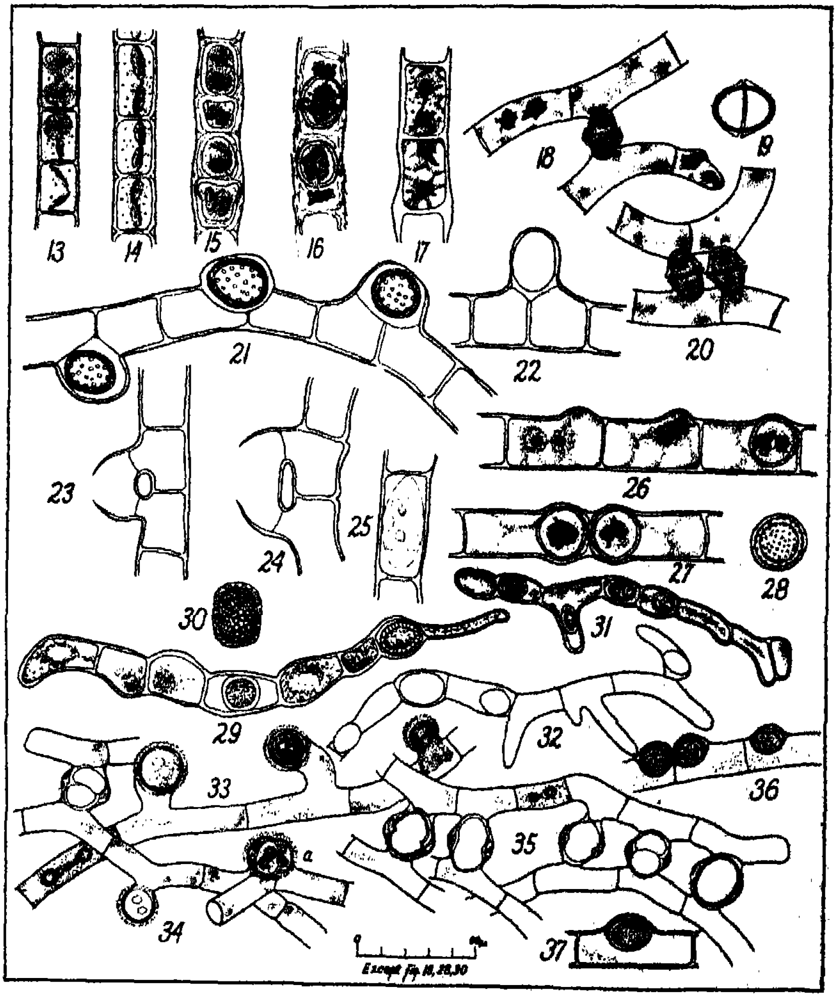
Figs. 29-32. *Zygogonium hansgirgi* showing aplanospores, after Schmidle, 1900.

Figs. 33-35. *Zygogonium ericetorum* from Kwong Tung, China, (McClure Collection). Showing zygospores, aplanospores, and parthenospores. At (34a) partial fusion of three encysted gametes. These specimens were growing on moist soil, and the stages in conjugation are very similar to Hodgett's figures.

Figs. 36-37. *Zygogonium talguppense* from Mysore Province, India, showing aplanospores, after Iyengar.

PLATE I.

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DISTRIBUTION AND FLOWERING IN WOLFFIA PAPULIFERA.

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It has been supposed for some time that the Pointed Duckweed (*Wolffia papulifera* Thompson) occurred only in the type locality in Missouri. During a taxonomic and anatomical study of the genus *Wolffia* in eastern North America, however, the writer brought to light additional localities where this interesting species has been found.

The following is a list of the stations where the plant is known to have been collected. The writer has examined the material from each station with the exception of those reported by Bravo from near Mexico City, and Bush from Kennett, Missouri, the latter being checked by Thompson.

Locality	*Date*	*Collector*
Kennett, Missouri, U. S. A.	1895	B. F. Bush.
Columbia, Missouri, U. S. A.	1897	C. H. Thompson.
Linn Co., Kansas, U. S. A.	1897	A. S. Hitchcock.
Mexico City, Mexico	1930	H. Bravo.
Latonia, Kentucky, U. S. A.	1931	D. M. Brown.
Jackson Co., Ohio, U. S. A.	1932	R. B. Gordon.
Southern Campeche, Mexico	1932	C. L. Lundell.

During the summers of 1927 and 1928, Saeger collected some material from the type locality in Missouri which bore flowers. The present writer has also found flowers on the material collected by Lundell in Campeche. These two collections are the only ones known to contain plants bearing flowers.

The writer wishes to thank all those who have furnished material for identification and study, the more complete results of which are to be included in a forthcoming paper on the taxonomy and anatomy of the genus.

LITERATURE.

Bravo, Helia. Las Lemnaceas del Valle de Mexico. Anal. del Inst. de Biol. Universidad Nacional de Mexico, 1: 7–32. 1930.

Saeger, Albert. The Flowering of Lemnaceae. Bull. Torrey Bot. Club, 56: 351–358. 1929.

Thompson, C. H. A Revision of the American Lemnaceae Occurring North of Mexico. Ann. Rept. Mo. Bot. Gard., 9: 21–42. 1898.

SOME EFFECTS OF VARYING AMOUNTS OF NITROGEN ON THE GROWTH OF TULIP POPLAR SEEDLINGS.*

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INTRODUCTION.

While many studies have been made on both the more general and the detailed effects of different amounts of available nitrogen on several horticultural and crop plants, few investigators have given much consideration to comparable problems relative to forest tree species. It is known, however, that plants in general under these conditions make somewhat similar responses in leaf color and vegetative organs, but that the more detailed behavior varies widely. The present study began with one year old seedlings of tulip poplar (*Liriodendron tulipifera*, L.). Stock of this important forest tree species is commonly produced in forest nurseries for reforestation projects in the eastern states. As the survival of transplants is often largely dependent upon the quality of stock itself, it seems that a knowledge of the behavior of a particular species grown under different nitrogen conditions is essential to production of desirable seedlings.

Hesselman (1917) in his study of the subordinate vegetation associated with regenerating coniferous forests has listed two general groups of plants based on the form of accumulated nitrogen compounds found in the tissues. Those which contain nitrate nitrogen are called "nitratophilous plants," even though they give nitrate tests only when grown in soils high in nitrogen. The other group includes those species which do not show an accumulation of nitrate nitrogen under similar conditions.

Schimper (1890) found quite inconsiderable amounts of nitrate nitrogen in the tissues of tree seedlings grown on compost soil very rich in nitrates. From analyses made on various parts of apple trees on plots which had been supplied with varying quantities of nitrate nitrogen, Gourley (1915) found

*Papers from the Department of Botany, The Ohio State University, No. 315.

no correlation between the amounts of nitrate nitrogen in the tissues and the amounts added to the soil. In all cases, the nitrate nitrogen present in the trees was almost negligible.

Busgen (1917) quotes Ebermayer (1882) as having found the woody cylinder poor in nitrogen, 0.17 percent of its dry weight. Fallen leaves of beech, spruce, and pine contained 1.34, 1.06, and 0.91 percent respectively of nitrogen. Dried green leaves of oak and elm at the end of July showed 2.30 and 1.87 percent nitrogen. He estimated that the nitrogen requirement per acre per year for the beech forest is 45.5 pounds. According to Passler (1893), most of the nitrogen absorbed by roots accumulates in the leaves, only one-fourth to one-fifth is stored in the stem. Gaumann (1928) found 0.07 and 0.08 percent protein respectively for the heartwood and sapwood of *Abies pectinata* and 0.05 and 0.06 percent protein for the heartwood and sapwood of *Picea excelsa.*

According to Falkenstein (1913), Hesselman (1917), Weidmann (1924) and others, nitrate nitrogen seems to be the best source of nitrogen for forest trees. The "more exacting" broad-leaved tree species, especially the young growths, respond well to nitrification in the soil. Wherry (1926) reports studies in Finnish forests by Ilvessalo (1923) which show definite correlations between the increment of the trees and nitrogen content of the soil. Fertilizer investigations at the Savenac forest nursery, Haugen, Montana, by Wahlenberg (1930) showed that seedlings given a heavy application of a nitrogenous compost were twice as tall and had much thicker stems than plants in check plots.

From investigations on tomato plants, Kraus and Kraybill (1918) described the relationship between the amount of available nitrogen and the development of shoot and roots, that is, a high nitrogen supply is associated with a greater shoot than root growth, and a low nitrogen supply is associated with a greater root than shoot growth. Wahlenberg's work also shows a shoot-root ratio of 2.2 for heavily fertilized Englemann spruce seedlings, based on oven-dry weights, as against 1.75 for unfertilized seedlings. Chandler (1919) in a study of peach trees, concluded that the addition of nitrates to the soil is associated with a greater development of top than roots.

Wahlenberg observed that many thrifty, dominant Engelmann spruce seedlings in heavily treated beds develop yellowish tips on mature needles quite unlike the yellowishness of needles

developed in poor soil. Reid (1930) observed mottling in squash leaves after extra nitrogen was supplied.

The purpose of this paper is to describe the effects of different quantities of ammonium nitrate upon the distribution of nitrogen compounds and growth responses in tulip poplar seedlings under a given environment.

PRODUCTION OF EXPERIMENTAL MATERIAL.

One year old tulip poplar seedlings were used in these experiments. They were selected from a lot obtained late in November, 1929, from the state forest nursery near Marietta, Ohio. The selected seedlings were placed in cold frames where they remained until March 15, on which date they were potted in one-gallon, white, glazed, earthenware jars.

TABLE I.

AMOUNT OF AMMONIUM NITRATE ADDED PER JAR IN EACH UNIT OF FIVE AND THE NITROGEN EQUIVALENT PER ACRE OF 2,000,000 POUNDS OF SOIL.

Unit	Number Plants in Unit	Grams of NH_4NO_3	Pounds of N per Acre
1............	5	0.000	0
2............	5	0.142	20
3............	5	0.284	40
4............	5	0.710	100
5............	5	1.420	200
6............	5	2.840	400

Clermont silt loam was used as the medium for growth, principally because of its small content of organic matter. The air-dry soil was thoroughly mixed and sifted through a 36-mesh sieve to insure uniform composition. A definite amount of the silt loam, 5520 grams, was placed in each of thirty weighed jars after nitrogen in the form of ammonium nitrate had been thoroughly mixed with the soil of each unit except that of five check jars.* Table I gives data for the addition of nitrogen. An estimation of the amount of nitrogen absorbed by the seedlings during the first season showed it necessary to make a second similar application of ammonium nitrate in the spring of 1931.

The optimum moisture content of the soil was taken as 50 percent of the amount of water necessary for saturation,

*The term, "unit," will be used to designate any group of five jars having similar applications of nitrogen.

(Ref. in Emerson, 1925). After transplanting a weighed seedling to each jar, enough distilled water was added to give the desired moisture content.* While it was not possible to keep the moisture content of the soil constant, check weighings were made from time to time. Rapid evaporation from the soil surface was prevented by covering the top of each jar with a circle of paraffined cardboard.

The potted plants were arranged on tables in a greenhouse room where they remained during the two growing seasons. In order that the effects of the environmental factors might be equalized for all plants, the jars were frequently shifted on the tables. They were placed in cold storage from November 1, 1930, to March 15, 1931.

In an attempt to avoid any introduction of a non-nitrogenous base as a variable soil factor which might greatly influence the concentration of hydrogen ions, ammonium nitrate was used as the source of nitrogen. On May 25, 1930, the pH value of a soil solution from each unit was determined by means of a quinhydrone potentiometer. Following are the results:

Units	1	2	3	4	5	6
pH value	4.88	4.88	4.64	4.55	4.44	4.44

Ten c. c. of distilled water and 10 grams of air-dry soil were thoroughly mixed to obtain a solution.

Total nitrogen determinations by the modified Kjeldahl method on the Clermont silt loam, before additional nitrogen was supplied, showed 600 pounds per acre.† Further total nitrogen determinations were made at the conclusion of the experiment on the soil of each unit, giving the following results:

Units	1	2	3	4	5	6
Pounds of N. per acre based on air-dry weight	300	560	640	760	840	980

Ten gram samples in duplicate were used for each determination.

*All water used throughout the two growing seasons was distilled.

†All necessary corrections for the reagents were made in nitrogen determinations by the Kjeldahl method.

TABLE II.

MAXIMUM AND MINIMUM RANGES OF AIR TEMPERATURE AND RELATIVE AIR HUMIDITY INSIDE THE GREENHOUSE FOR GROWING SEASONS OF 1930 AND 1931.

TEMPERATURE.

1930	May	June	July	Aug.	Sept.	Oct.	Nov.
Range of max. temp.	60–105	70–102	82–107	70–105	66–92	59–93	83–101
Range of min. temp.	47–67	49–75	49–78	47–77	44–65	41–73	69–77
Max. range any one day	67–105	64–102	58–104	54–100	47–88	41–81	72–101
Min. range any one day	61–71	62–78	67–82	61–70	61–66	70–73	76–83

RELATIVE AIR HUMIDITY.

1930	May	June	July	Aug.	Sept.	Oct.	Nov.
Range of max. hum.	52–89	69–95	61–95	61–95	79–95	52–94	41–61
Range of min. hum.	13–72	24–79	20–55	19–88	22–78	15–73	10–55
Max. range any one day	29–89	24–85	30–92	19–91	28–91	21–80	10–50
Min. range any one day	72–84	79–95	55–89	88–95	72–91	65–68	55–61

TEMPERATURE.

1931	Mar.	April	May	June	July	Aug.	Sept.
Range of max. temp.	73–96	66–101	66–99	85–105	88–106	73–105	75–108
Range of min. temp.	60–76	46–74	54–70	57–77	58–78	59–78	59–78
Max. range any one day	60–96	55–101	60–99	62–102	66–102	69–104	66–107
Min. range any one day	60–73	68–75	62–70	61–85	65–80	64–73	78–87

RELATIVE AIR HUMIDITY.

1931	Mar.	April	May	June	July	Aug.	Sept.
Range of max. hum.	50–77	45–96	50–90	70–90	69–87	69–90	80–89
Range of min. hum.	25–59	17–75	23–75	23–65	18–67	22–81	30–72
Max. range any one day	28–77	30–96	23–82	23–81	21–82	28–84	30–81
Min range any one day	49–51	75–80	75–84	81–89	67–87	81–89	72–89

During the course of the experiment, no attempt was made to control the atmospheric factors of the environment other than reducing the light intensity which otherwise had deliterious effects upon the seedlings on bright summer days. This was accomplished by coating the greenhouse glass with a lime-sodium chloride-water mixture not easily washed away by rain. Measurements of such major factors as air temperature, relative air humidity, and soil temperature were made, and relative light intensity was compared with that of full daylight.

Air temperature and relative air humidity (Table II) were recorded on charts by a hygro-thermograph which remained throughout both seasons near the center of the group of potted plants.

TABLE III.

MAXIMUM AND MINIMUM RANGES OF SOIL TEMPERATURE FOR GROWING SEASONS OF 1930 AND 1931.

Temperature.							
1930	May	June	July	Aug.	Sept.	Oct.	Nov.
Range of max. temp.......	56-88	60-87	68-89	70-88	61-88	56-80	68-81
Range of min. temp.......	45-68	52-76	57-78	60-81	58-72	55-72	70-76
Max. range any one day...	65-82	68-84	64-87	65-78	66-81	58-76	70-78
Min. range any one day...	70-76	67-74	72-82	68-79	67-78	63-70	66-70
Temperature.							
1931	May	June	July	Aug.	Sept.	Oct.	Nov.
Range of max. temp.......	63-78	67-84	68-86	72-90	68-88	74-91	64-87
Range of min. temp.......	63-72	58-70	57-69	62-78	65-80	68-79	66-81
Max. range any one day...	68-82	62-84	73-82	69-85	73-87	70-86	68-83
Min. range any one day...	73-78	64-73	68-74	75-87	72-80	69-77	67-78

The soil temperature (Table III), recorded by a soil thermograph, showed much more uniform diurnal changes and a much narrower range than the air temperature. The daily maximum temperature usually trailed the maximum air temperature approximately one to one and one-half hours, occurring from two-thirty to three-thirty o'clock in the afternoon.

The Eder-Hecht "Graukeil" photometer with Solio paper, was used to determine the total light intensity of the daylight period inside and outside the greenhouse for various periods throughout both seasons. In all instances, the photometers

were loaded and placed in a horizontal position one night and read the following night. If the out-of-doors reading each time is assumed to be 100, at no time did any one of the simultaneous indoor readings fall outside the range, 83–92. The relation existing between the accumulative light intensity to which the seedlings were exposed and that of full daylight of a cloudy day did not vary from a similar relation on a clear day. These measurements are not intended to give the absolute intensities in both situations, but to show the relative intensity of light to which the seedlings were exposed as compared with that of full daylight.

Measurements of other environmental factors are not offered in an attempt to explain any correlation that may exist between them and the behavior of the plants, but as partial description of the conditions under which the seedlings were grown.

The plants were removed from the jars on September 15, 1931, the soil carefully washed from the roots and all necessary measurements made.

NITROGEN CONTENT OF PLANTS.

The analyses of the tulip poplar seedlings include both nitrate and total nitrogen determinations. These were made on the root, bark, and woody cylinder of plants of the original lot at the time of potting and of plants of each unit at the conclusion of the experiment and on the leaves of each unit at the end of each growing season, including leaves which fell during the period.

Methods.—The material from each part of the plants was weighed on analytical balances and dried to constant weight at 85° C. It was then transferred to weighed, ether extracted extraction thimbles, each loaded thimble weighed and extracted with 80 percent ethyl alcohol until the extract became clear, usually for a period of ten to twelve hours. The extracted loaded thimbles were dried in an 85° C. oven to constant weight. The extractions were made with Soxhlet extractors attached to water-jacketed condensers. Constant heat was applied by means of an electric hot plate.

The content of each thimble was at once finely ground in a food pulverizer and stored in a tightly stoppered vial. The extract was made up to volume, at 20° C., with 80 percent

ethyl alcohol on the basis of one liter of extract for 50 grams of fresh material. The solution was kept in rubber stoppered Erlenmeyer flasks until analyses could be made.

Nitrate and total nitrogen, including nitrate nitrogen, determinations were made on the extracts. Aliquots of 100 c. c. of each alcoholic extract, placed in 800 c. c. Kjeldahl flasks, were evaporated down to 10 c. c. After the samples had cooled, 400 c. c. of distilled water was added. The solution was made slightly alkaline by the addition of a few drops of 50 percent sodium hydroxide. A small amount of Devarda's alloy was mixed with the contents of each flask to reduce any nitrate nitrogen present to ammoniacal nitrogen. The flasks were immediately connected with a still and distillation carried

TABLE IV.

Percent of Nitrogen Based on Both Fresh and Dry Weight of Seedlings from Original Lot.

Plant Part	On Fresh Weight Basis			On Dry Weight Basis		
	Alcoholic Extract	Residue	Total N	Alcoholic Extract	Residue	Total N
Bark	0.09	0.58	0.67	0.18	1.22	1.40
Woody cylinder	0.08	0.14	0.22	0.16	0.26	0.42
Root	0.10	0.26	0.36	0.33	0.87	1.20

on slowly for an hour. The receiving flasks contained 50 c. c. of saturated solution of C. P. boric acid, approximately a 4 percent solution. As any ammonium was bubbled into the acid solution, ammonium borate was formed. This was then titrated with N/14 sulphuric acid. By simple calculations, the amount of nitrate nitrogen present was found.

Approximately 35 c. c. of concentrated sulphuric acid and 10 grams of a salt mixture of potassium sulphate, ferrous sulphate, and copper sulphate, in the proportion of 10 to 1 to 0.5, were added to the remaining content of each Kjeldahl flask and the whole placed over a gas flame until digestion of all organic matter was complete. After cooling, 400 c. c. of water was added to each flask and the content made decidedly aklaline with 50 percent sodium hydroxide. Distillation was again carried on for one hour. As for nitrate nitrogen, the receiving flasks contained 50 c. c. of a saturated solution of boric acid and after distillation titrated with N/14 sulphuric acid.

TABLE V.

PERCENT OF NITROGEN BASED ON BOTH FRESH AND DRY WEIGHT OF LEAVES OF 1930 GROWING SEASON AND OF ALL PLANT PARTS FOR 1931 SEASON.

Basis for Calculation of N Percent	Material Analyzed	Pounds of N Added per Acre per Year					
		0	20	40	100	200	400
Leaf, 1930.							
Fresh weight	Alcoholic extract	0.04	0.09	0.12	0.15	0.18	0.23
	Residue	0.10	0.12	0.13	0.14	0.17	0.18
	Total	0.14	0.21	0.25	0.29	0.35	0.41
Dry Weight	Alcoholic extract	0.05	0.11	0.15	0.18	0.23	0.29
	Residue	0.51	0.62	0.63	0.71	0.88	0.91
	Total	0.56	0.73	0.78	0.89	1.11	1.20
Leaf, 1931.							
Fresh Weight	Alcoholic extract	0.02	0.03	0.05	0.09	0.11	0.25
	Residue	0.28	0.37	0.41	0.56	0.65	0.90
	Total	0.30	0.40	0.46	0.65	0.76	1.13
Dry weight	Alcoholic extract	0.08	0.16	0.24	0.44	0.54	1.16
	Residue	0.95	1.36	1.45	2.11	2.35	3.89
	Total	1.03	1.52	1.69	2.55	2.89	5.05
Bark, 1931.							
Fresh weight	Alcoholic extract	0.03	0.04	0.06	0.07	0.16	0.20
	Residue	0.35	0.46	0.59	0.69	0.82	1.23
	Total	0.38	0.50	0.65	0.76	0.98	1.43
Dry Weight	Alcoholic extract	0.06	0.07	0.15	0.17	0.37	0.46
	Residue	0.61	0.83	1.10	1.25	1.47	2.06
	Total	0.67	0.90	1.25	1.42	1.84	2.52
Woody Cylinder, 1931.							
Fresh weight	Alcoholic extract	0.01	0.03	0.06	0.07	0.08	0.15
	Residue	0.21	0.24	0.32	0.32	0.33	0.37
	Total N	0.22	0.27	0.38	0.39	0.41	0.52
Dry weight	Alcoholic extract	0.02	0.06	0.12	0.13	0.15	0.27
	Residue	0.39	0.40	0.53	0.54	0.55	0.61
	Total N	0.41	0.46	0.65	0.67	0.70	0.88
Root, 1931.							
Fresh weight	Alcoholic extract	0.06	0.15	0.24	0.35	0.40	0.55
	Residue	0.24	0.39	0.51	0.64	0.81	0.98
	Total N	0.30	0.54	0.75	0.99	1.21	1.53
Dry weight	Alcoholic extract	0.19	0.51	0.83	1.18	1.37	1.80
	Residue	0.61	0.89	1.23	1.70	2.11	2.55
	Total N	0.80	1.40	2.06	2.88	3.48	4.35

Similar modifications of the Kjeldahl method were employed in determining the total nitrogen of the extracted residue as in the analysis of the extracts. Two gram samples of the residues were used.

Checks were run to detect any nitrogenous impurities in the reagents.

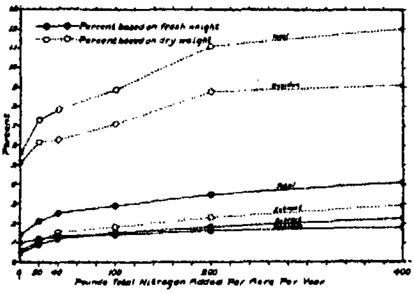
Results.—The results obtained from the analysis include in the extract those nitrogen compounds soluble in 80 percent ethyl alcohol and in the residue the nitrogen compounds insoluble in 80 percent ethyl alcohol. Each form is expressed in percent based on both fresh and dry weight of the plant part analyzed. Also, the total nitrogen, including nitrates, is shown for each of the plant parts in Tables IV and V. Since in no case was there enough nitrate nitrogen found to exceed the limit of experimental error, no further record has been made of these findings.

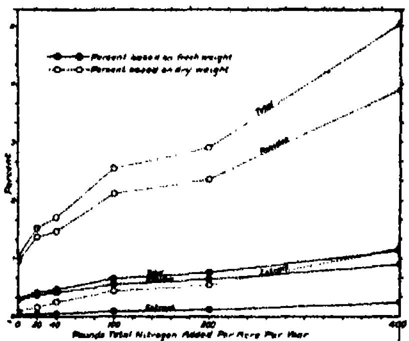
Figures 1, 2, 3, 4, and 5 show more clearly the relationship existing between the nitrogen content of the soil and the distribution of nitrogen in the seedlings.

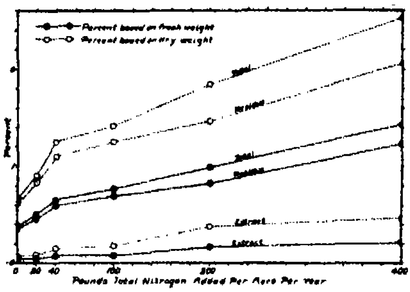
Discussion.—Table V shows in detail the distribution of nitrogen in the seedlings. It may be observed that the percent of total nitrogen in the several parts of the plants analyzed increases with the increase of nitrogen in the soil medium. It may also be noted that the ratio between the percentage of total nitrogen in each plant part and that of its soil medium is not a constant one throughout the series. The nearest approach to a constant ratio occurs for the leaves of the 1931 season. While both the soluble and insoluble nitrogen in 80 percent ethyl alcohol increase with the soil nitrogen, the rate of increase of the latter is somewhat the smaller of the two in most cases. Total nitrogen, based on dry weight, was present in the greatest abundance in the leaf material and decreased in order in the root, bark, and woody cylinder. The woody cylinder was the only part which contained less than one percent of total nitrogen in all units, the alcohol soluble nitrogen being exceptionally small. The high percentage of nitrogen found in the leaves corresponds closely to the results of investigations by Ebermayer of various tree species.

If tulip poplar were a nitrate accumulating species, one would have expected an increase of nitrogen in the plant, corresponding to the increase of the element in the soil, but

such did not occur. It is evident that a greater percentage of nitrogen was absorbed by plants of the units high in nitrogen than those containing a small amount; but analyses showed that, even though the nitrate nitrogen had entered the plant as such, it was transformed almost immediately into some other soluble form.







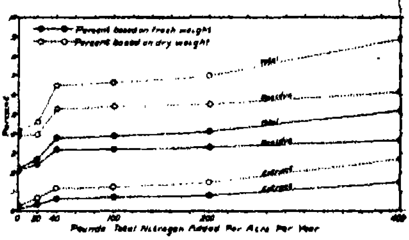


FIGURE 1. (*Upper left.*) Percentage of nitrogen, based on both fresh and dry weight, present in 1930 season leaves from the six units.

FIGURE 2. (*Upper right.*) Percentage of nitrogen, based on both fresh and dry weight, present in 1931 season leaves from the six units.

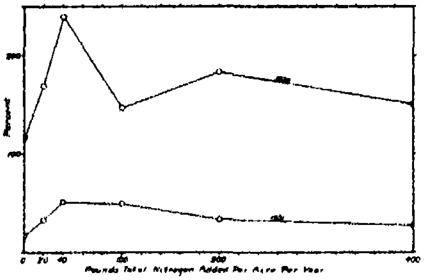
FIGURE 3. (*Lower left.*) Percentage of nitrogen, based on both fresh and dry weight, present in bark from the six units.

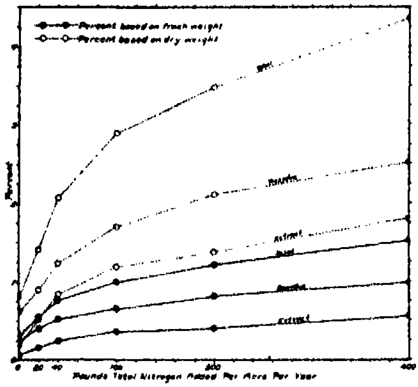
FIGURE 4. (*Lower right.*) Percentage of nitrogen, based on both fresh and dry weight, present in woody cylinder from the six units.

GROWTH RESPONSES.

Effects of Nitrogen on Leaf Color.—As early as the middle of July, 1930, very distinct differences in the green color of the leaves had developed in seedlings supplied with the varying amounts of nitrogen. This condition was quite noticeable throughout the remainder of the first season and all of the 1931 growing season. Leaves of the check plants were decidedly greenish-yellow. Those on the plants showing the higher growth rates contained the smaller quantity of chlorophyll.

Many of the mature leaves in the middle and upper parts of the crowns showed a browning of only the tips and persisted for several weeks, while some of the lower leaves became entirely brown and abscissed. The green pigment was somewhat better developed in the seedlings of unit two. All leaves of unit three except a few on one plant appeared much darker





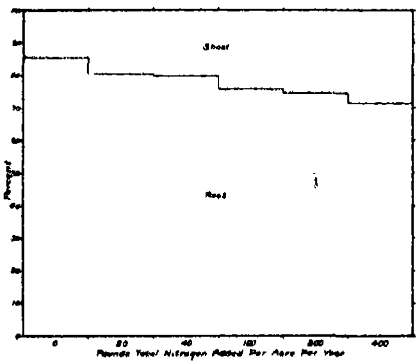


FIGURE 5. (*Lower left.*) Percentage of nitrogen, based on both fresh and dry weight, present in roots from the six units.

FIGURE 6. (*Upper.*) Relative percent increase in height of seedlings for growing seasons of 1930 and 1931.

FIGURE 7. (*Lower right.*) Percentage of shoot and root based on the total fresh weight of the individual units.

green in color. In units four and five, the leaves had a uniform dark green color; none of the lower ones showed browning. In the leaves of unit six, there appeared a blotching of yellow and green on the mature and overmature leaves. The latter soon turned brown and abscissed. Only the young leaves were free of the mottled effect.

It has been generally observed that a uniform yellowish-green color of leaf accompanies, in most plants, low available

nitrogen, which limits the development of chlorophyll. The green and yellow mottled effect of leaves associated with an excess of available nitrogen is due to a decomposition of chlorophyll after the development of a dark-green color in the early

TABLE VI.

VARIOUS STAGES OF EACH SEEDLING IN THE BREAKING OF DORMANCY IN THE SPRING OF 1931.

DATE OF OBSERVATION	CONDITION OF PLANT	POUNDS OF N ADDED PER ACRE PER YEAR																													
1931		0					20					40					100					200					400				
		Individual Plants																													
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
March 24	Buds swelling																														
	Buds bursting																														
	Leaves unfolding	x	x		x	x														x	x		x	x	x	x	x	x		x	x
	In full leaf																														
March 30	Buds swelling																x														
	Buds bursting						x	x		x				x		x		x	x			x									
	Leaves unfolding			x								x	x		x											x			x		
	In full leaf	x	x		x	x														x	x		x	x	x		x	x		x	x
April 5	Buds swelling																														
	Buds bursting								x																						
	Leaves unfolding							x		x				x		x	x	x	x												
	In full leaf	x	x	x	x	x	x				x	x	x		x					x	x	x	x	x	x	x	x	x	x	x	x
April 11	Buds swelling																														
	Buds bursting																														
	Leaves unfolding																														
	In full leaf	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

stages of growth. The concentration of nitrogen in the soil medium, at which mottling appears, depends upon the amount immediately available. Since nitrogen in the form of ammonium nitrate was at once available and there was no leaching from the jar, the toxic effect for tulip poplar appeared at a comparatively low concentration. The writer (1931) found mottling

in white elm leaves grown under the same conditions as the mottled tulip poplar leaves.

Relative Dormancy.—Both the time at which dormancy began in the autumn and the time of breaking of dormancy in the spring were relatively earlier, the greater the concentration of nitrogen in the soil medium. As previously mentioned, lower leaves of the seedlings at the limits of the series were turning brown and abscissing as early as July 15; leaf fall continued from these plants until none remained on those in unit six by September 25. A week later, leaf fall for the seedlings of units one and two was complete. A few leaves still persisted, and many terminal buds showed active growth on the plants of units three, four, and five at the time of storage, November 15. Buds showing active growth in the late autumn were killed by the low temperatures during storage.

TABLE VII.

PERCENT INCREASE IN HEIGHT OF SEEDLINGS FOR GROWING SEASONS OF 1930 AND 1931, BASED ON HEIGHT AT BEGINNING OF EACH SEASON.

Average Percent Increase for Season	Pounds of N Added per Acre per Year					
	0	20	40	100	200	400
1930	117.7	169.8	241.4	147.0	184.6	151.0
1931	16.6	34.4	51.0	49.6	33.0	27.4

During the following spring, the plants of the series broke dormancy in the same order as dormancy began. Table VI shows the various stages of each seedling in the breaking of dormancy as observed at intervals of six days.

The time of beginning and breaking of dormancy of a species is of considerable ecological importance, and results for tulip poplar show that high and low available nitrogen favor an early beginning and early breaking of dormancy while intermediate quantities of available nitrogen favor a later beginning and a later breaking of dormancy.

Height Increase During Growing Season.—The increase in height of all plants was determined in centimeters for each of the growing seasons. The average increase for each unit was calculated and its percentage of the average original height of the seedlings in the unit found for the first season. The

percent increase for the second season was based not on the average original height, but on the average height at the beginning of the second season. The results of the measurements are shown in Table VII.

To more clearly show the dissimilarity between the results of the two seasons' growth, they have been further recorded in graph form, Figure 6 (page 175).

It may be noted from Table VII and Figure 6 that, during the 1930 season, the seedlings did not show a height growth curve similar to that of the 1931 season. The irregularity is perhaps due to a "transplanting shock," principally a disturbance of the root systems. Wahlenberg, who tested the effects of various amounts of nitrogen on Engelmann spruce seedlings, found "Increases in growth were slight and, . . . , were not in evidence until the second year, even though the fertilizer used was in readily soluble form. During its first year a tree seedling naturally expends much energy in root development at the expense of top growth. After having spent a year developing roots it seems better able to absorb nutrients and use them for further growth of the seedling as a whole, especially for top growth."

TABLE VIII.

Average Percentage of Increase in Fresh Weight of Tulip Poplar Seedlings Over the Weight at Time of Potting.

	Pounds of N Added per Acre per Year					
	0	20	40	100	200	400
Average percent increase in weight. . .	132.5	263.8	356.8	432.2	317.4	260.8

Total Increase in Weight.—The total percent of increase of weight of the seedlings was based upon an average of the original weight of the one year old seedlings and final fresh weights for each unit. In either case, the plants were weighed without leaves, and the results in Table VIII do not include leaf weight. The combined leaf material for each unit for both seasons has a similar relation to the concentration of nitrogen in the soil as that of the plants as weighed.

Probably, the best indication of favorable conditions for growth of plants is the increase in weight. Table VIII shows

that of the six media used the medium of unit four afforded these conditions. A close parallelism exists between data of Tables VII and VIII.

Shoot-to-Root Ratios.—At the conclusion of the investigation, the plants of each unit, carefully washed and dried with blotting paper, were cut into two parts, roots and shoots, and weighed separately. All fibrous roots broken in removing the plants from the soil medium were sifted out and included in the weights. Due to the decay and sluffing off of numerous small roots of plants of unit six, the shoot-root ratio for that group may be slightly too high. Figure 7 contains the shoot and root percentages based on the total fresh weights of the individual units.

TABLE IX.

AVERAGE SHOOT-ROOT RATIOS BASED ON FRESH WEIGHT FOR THE PLANTS OF EACH UNIT.

	POUNDS OF N ADDED PER ACRE PER YEAR					
	0	20	40	100	200	400
Shoot-root ratios.....	0.15	0.24	0.24	0.32	0.33	0.38

While the ratios of shoots to roots, Table IX, based on fresh weights are not necessarily indicative of the kinds or quantity of shoots and roots produced, they are an expression of the relative growth rates in the two organs. The fact that there existed a very small difference in the moisture content of similar tissues of plants grown in soil media with varying amounts of nitrogen makes the data more significant. This difference was much less than the difference in succulence of the seedlings indicated. It may be seen from the data, Figure 7 and Table IX, that the large shoot in proportion to the root is associated with a high amount of nitrogen in the soil and the small shoot in proportion to root with a deficiency of nitrogen.

SUMMARY.

The effects of various amounts of nitrogen on potted tulip poplar seedlings have been studied, and the following summary statements are based on plants grown only under the set of conditions described.

1. An insignificant amount of nitrate nitrogen accumulated in the tissues of tulip poplar seedlings regardless of the concentration of ammonium nitrate added to the soil medium.

2. Alcohol soluble nitrogen existed in much smaller quantities in plants of all units than did the alcohol insoluble nitrogen. While the rate of increase of both the soluble and insoluble nitrogen increased with the amount of the nitrate salt supplied, the rate of increase of the soluble form in the seedlings was much greater.

3. The total nitrogen, including nitrate nitrogen, was most abundant in the leaf and decreased in order in the root, bark, and woody cylinder.

4. (a) Leaves of plants supplied with little or no extra nitrogen had uniformly yellowish-green leaves.

(b) Leaves of plants supplied with additional nitrogen equivalent to 40, 100, and 200 pounds per acre had a uniformly dark-green color.

(c) Leaves of plants supplied with the highest amount of additional nitrogen developed at maturity a mottled green and yellow color.

5. Plants growing in the soil media having the highest and lowest concentrations of nitrogen began and broke dormancy relatively earlier than plants of the other units.

6. No definite correlation was noted between the height growth of the seedlings and the amount of the available nitrogen during the first season after transplanting. However, the greatest average height was attained during the second season by plants grown in soil media with nitrogen equivalents of 40 pounds and 100 pounds added per acre per year, the heights decreasing with greater and smaller amounts.

7. The greatest average weight of plants occurred with the addition of the equivalent of 100 pounds of nitrogen per acre, the average weights decreasing with the increase and decrease of nitrogen.

8. An increase of the shoot-root ratio was associated with the increase of the nitrogen supply.

The writer wishes to express his appreciation for helpful suggestions and criticisms to Drs. E. N. Transeau and H. C. Sampson, of the Department of Botany, Ohio State University, Dr. J. T. Auten, of the Central States Forest Experiment Station, and Prof. E. F. McCarthy, of the New York State College of Forestry, Syracuse University, and former director of the Central States Forest Experiment Station.

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The Problem of Teaching.

This volume presents the results of service studies carried on by various teachers and administrators of the Ohio State University. While these studies were of necessity attempts to solve particular problems in specific locations in the educational field, the methods used and the results achieved are of wide significance. No one interested in the progress of education can afford to overlook them.

Modern methods of teaching are discussed by those using them; the results of modern methods of teaching are viewed through the medium of suitably prepared objective examinations. Remedial methods for the students not responding normally, as well as special methods and encouragement for the superior students, are developed. Broad surveys of general fields round out the volume, which is a real contribution to higher education.—L. H. S.

Service Studies in Higher Education, by eighteen members of the staff of the Ohio State University. VIII + 283 pp. Bureau of Educational Research Monographs, No. 15. Columbus, Ohio State University, 1932. $2.00.

COLOR IN VARIOUS PLANT STRUCTURES AND THE SO-CALLED PRINCIPLE OF SELECTIVE ADAPTATION.

Studies in Determinate Evolution, VII.*

JOHN H. SCHAFFNER,
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In the lowest, living vascular plants there is usually very little color aside from the general green of the chlorophyll. This applies to the ferns, the flowerless clubmosses, and even to the lower, flower-bearing clubmosses and horsetails. In the higher clubmosses the cones sometimes become yellow and the highest horsetails have their fertile shoots and cones destitute of the green color of the sterile shoots. As one progresses upward through the flower series to the higher plants, more color is evolved and usually not only a greater diversity of tints in the various species, but also a much more complicated color chemistry in the individual petals and other parts, distributed in spots, dots, stripes, blotches, etc. This is because the higher plants as a general rule develop a more and more complex system of hereditary potentialities which come into play with the complex physiological gradients and states initiated in the developing inflorescence, flowers, and fruits and also in the purely vegetative parts.

In the general evolution of the flower, the movement is continually toward a more prompt determination of the floral axis, which commonly results in very small flowers as the final condition. In the more extreme reductions there is thus a strong tendency to eliminate the color because the corolla or even the entire perianth is lost. Thus in both bisporangiate and monosporangiate species the flower clusters are often almost destitute of color. The crowding of small flowers in the higher types of inflorescences may, however, compensate for this reduction movement and the color display may also appear farther down the axis, even in the leaves below the inflorescence. Sometimes then in monosporangiate inflorescences there are prominent displays of color even though the individual units

*Papers from the Department of Botany, The Ohio State University, No. 308.

are inconspicuous. In such species as *Populus deltoides* Marsh. the staminate catkins are a very conspicuous purple-red because of the red anthers, but the carpellate catkins are inconspicuous because of the pale green color of the ovularies. In some of the intermediate types of flowers like many of the pines, larches, firs, and spruces, the color display is very conspicuous, both because of the intensity of the color itself and because of the size of the cones. Many of the wind pollinated gymnosperms have very conspicuous and showy strobili, both staminate and carpellate, as for example, *Picea abies* (L.) Karst. Some are also very fragrant, like the staminate cones of *Dioon edule* Lindl. Of course, it would be quite ridiculous to claim that the color was to attract the wind, but not more so than to claim that specific colors were evolved to attract insects when we know that the ordinary insects, like the wind, may visit a great diversity of colors even in a single nectar-foraging expedition.

It is interesting to note that teleologists in their zeal to expound and prove the causal relation between color of flowers and insects have almost entirely lost sight of the great host of beautifully colored anemophilous flowers. A very extensive teleological literature on the color and form of flowers and on color patterns in general has been developed in the past hundred and forty years. In 1793 Christian Conrad Sprengel published his treatise on the structure of flowers with special reference to the aid of insects in their pollination. Sprengel said that, "Nature seems to have wished that no flower should be fertilized by its own pollen." This superficial notion became generally accepted after the publication of Darwin's book on the fertilization of orchids by insects, which appeared in 1862, and by papers published by Hermann Mueller in 1873 on pollination of flowers through the aid of insects. Darwin stated that "Nature abhors perpetual self-fertilization." Since for the next twenty-five years natural selection was generally assumed to be the causative agent in evolution, the color of flowers and fruits and color patterns in general furnished themes for whole libraries of books and papers on the subject.

As stated, during the years of rampant speculations of the neodarwinian teleology, one of the most universally exploited phenomena of the flowering plants was the prominent display in these plants of the color of flowers and fruits. All the diverse colors and endless patterns of streaks, lines, spots, dots, dashes, and nets were explained as being the result of a life and death

selecting action by insects and other animals which fed on the pollen, nectar, and fruits. Each spot was a recognition mark, each streak a line to guide the hungry or thirst insect to the proffered stores. Every fantastic pattern was of life and death utility to the possessor and had-been acquired through "natural selection" because of its survival value to the individual. The most remarkable phenomenon in this enthusiastic pursuit of pseudo-science was that its devotees never seemed to see the conspicuous and attractive colors in flowers that were visited only by the wind, never seemed to discover the bright colored lines and splotches so common on the stems and leaves of many weeds, whose flowers are not even noticed by insects, never speculated on the attractive value of the underground color of roots. The natural selection delusion followed the same course as have other delusions. The fantastic, teleological explanations exceeded anything ever imagined by the inventors of fairy stories to account for unsolved phenomena of nature. One could write volumes on the absurdities alone which have been perpetuated since the beginning of the twentieth century when De Vries with his mutation theory introduced a wholesome check, which should have brought to an end this unscientific era of "science." But though the teleological citidels of neo-lamarckism and neo-darwinism were badly battered by the mutation theory and the rediscovery of Mendelian heredity, the teleologist defenders did not surrender their beliefs but continue powerful in all lines of speculative philosophy and science up to the present time.

Especially preposterous are some of the Lamarckian explanations in some present textbooks of geology. Birds are said to have originated as follows: "These more active running and bipedal pro-avian lizards probably had their entire body covered with over-lapping scales, and jumping about from branch to branch or tree to tree, learned not only to parachute, but eventually to flop their front limbs in aviation. In these efforts the scales changed into long and complicated fronds and finally became feathers that maintained the body warmth," etc. "In the fishes, the paired fins with their girdles are the rudiments out of which legs and feet were developed through the enforced hobbling of the fringe-finned ganoids in their search for water holes in desert regions." Fishes got lungs in this way. "It is thought that under the stimulus of these changes gill-breathing fishes first adapted themselves to bur-

rowing in the sand. Thus protected in water and mud holes there was for a time moisture to pass over the gills, but under such environments life was very precarious and in the struggle most of the individuals were destroyed. After innumerable failures in their efforts to gulp the air into the pharynx, efforts lasting through long geologic time, the ganoids and lung fishes were gradually developed and perfected." It is difficult to imagine how credulity could invent anything more absurd than these statements.

In present university textbooks of botany, one can read that "butterfly flowers are frequently red, bee-flowers blue or purple." One need only watch a swarm of bees or bumble-bees at work to promptly discover that they exercise no such color preferences. The deductions are the result of philosophical belief rather than accurate observation. I have seen individual bees gathering nectar from flowers of almost every color of the rainbow in the space of a few minutes. The following is a dissertation on "honey-guides:" "In numerous flowers the entrance by which nectar is approached is marked by a ring or flush, colored differently from the rest of the flower, or lines and streaks converge upon it." Of course, one can find such rings and flushes or converging lines in all sorts of plant structures where no nectar is available for the unlucky insect that might be allured by such "guides."

The following is a sample of the popular science of a dozen years ago by a popular writer on nature themes. It is not one particle more ridiculous than what commonly appeared in the standard treatises put out by those who were considered leaders in the realm of scientific thought. "*The dandelion head.* Half the involucre bends downwards to protect the flower from crawling pilferers, half stands erect to play the role for the community of florets within that the calyx does for individual blossoms. Seated on a fleshy receptacle, not one flower, but often two hundred minute, perfect florets generously co-operate. In union there is strength. . . . Each floret of itself could hope for no attention from busy insects; united, how gorgeously attractive their disks of overlapping rays are! . . . Each floret insures cross-pollination from insects crawling over the head, much as the minute yellow tubes in the center of a daisy do. Quantities of small bees, wasps, flies, butterflies, and beetles—over a hundred species of insects—come seeking the nectar that wells up in each little tube and the abundant

pollen, which are greatly appreciated in early spring when food is scarce." Now it will be evident how ridiculous this teleological description is when it is known that our common dandelion is parthenogenetic, the eggs developing new plants without fertilization, and that neither the pollen nor the insects which spread it about are of any use whatever to the plant in its present condition. It has evolved into a highly efficient parthenogenetic species in direct contradiction to the supposed causative selection, produced by insects and its allurements of color and nectar.

Special colors may be present in all parts of plants and its development is due to the evolution of potentialities producing certain chemical reactions or diffraction surfaces which have no relation to survival of the species as the following examples will indicate:

Color of Pollen.—Pollen grains are of many colors. Sometimes they are of the same color as the anthers in which they are contained; sometimes they are of an entirely different color; sometimes the color corresponds with that of the petals, and sometimes it is of an entirely different tint. How foolish to think that the insect, after it had been attracted to the flower, would refuse to gather nectar or the pollen because it happened to be of a different tint from the petals or anthers. The colors of the pollen are as diverse as those of the rainbow. *Koellia incana* (L.) Ktz. has purple anthers and pure white pollen. *Staphylea trifolia* L. has yellow pollen and white petals. *Aesculus glabra* Willd. has orange pollen. *Iris-regelio-cyclas* hybrids (varieties Psyche, Parthenope, Luna, and Hebe) have green pollen. *Saponaria ocymoides* L. has bright blue pollen in blue anthers with a pink corolla as a background. *Geranium sanguineum* L. has blue pollen. *Echium vulgare* L. has light blue pollen. *Lilium pardalinum* Kell. and some other species of Lilium have red anthers and red pollen. *Aesculus hippocastanum* L. has pinkish red pollen. *Dianthus carthusianorum* L. has blue pollen and a dark red corolla. *Claytonia virginica* L. has white pollen in pink anthers. *Sedum ternatum* Mx. has pure white pollen in purple anthers. *Impatiens sultana* Hook. f. has pure violet-purple pollen. *Ipomoea purpurea* (L.) Lam. has pure white pollen. *Iris halophila* Pall. has bright orange pollen. *Leontodon taraxacum* L. has yellow pollen and a yellow corolla. *Lilium longiflorum* Thunb. has bright yellow pollen and white petals. *Linum usitatissimum* L. has white pollen

and a blue corolla. *Papaver orientale* L. has dark purple pollen in anthers of the same color and red petals. *Geranium maculatum* L. has light yellow pollen and light purple petals.

Some plants have pollen in two colors. In *Commelina communis* L. the two, upper, outer stamens have dull whitish pollen while the odd, upper, inner stamen has orange yellow pollen. These differences are caused by the zygomorphic condition and the advanced complexity of hereditary color factors as compared with its near relatives which have pollen of only one color, although the flower as a whole may have just as great a complexity of color potentialities. The duality of pollen color is dependent on the zygomorphic gradients developed in the determinate growth of the flower and not on any advantage or disadvantage to the species.

Why do plants have pollen of such diverse colors? For the same reason that corollas and other parts have such colors, but it is not to attract insects, nor for any other imaginary teleological purpose, but just as in the case of inorganic salts and rocks, so the various parts of living things show a great diversity of colors and color patterns as a part of the universal design of nature.

Color and Texture of Roots.—The parts of a plant that are continually underground are often as brightly colored as those exposed to the light of day and there is also a wide range of tints. In *Equisetum kansanum* Schaffn. and other species the rhizomes are pure black. *Physalis lanceolata* Mx. and *Xanthium pennsylvanicum* Wallr. have pure white roots. *Psoralea floribunda* Nutt. has light-brown roots. In *Toxylon pomiferum* Raf. the roots are orange in color. *Parosela enneandra* (Nutt.) Britt. has lemon-yellow roots. *Morus alba* L. has yellow-orange roots. *Celastrus scandens* L. has bright orange-red roots. *Amaranthus retroflexus* L. has pink roots. *Sansevieria thyrsiflora* Thunb., a common greenhouse species, has bright orange rhizomes and roots. Nearly all of these species, except *Sansevieria*, grow and are eminently successful in dry prairie soils where there are no essential physical differences. So a selectionist will have to fall back on biological factors to account for the differences and in a sarcastic mood it might be suggested that the black rhizomes of Equisetum are a protective coloration adaptation against the ravages of earthworms and gophers, and those roots with bright colors have an attractive value for the denizens of the underground realms of darkness.

Now the same general conditions and discrepancies in respect to color and environment exist above ground, but the enthusiastic, telelogical selectionists apparently never saw the misfits. They had eyes adjusted only according to their teleological or utilitarian faith.

In the same prairie soil the texture of roots also shows that there is no teleological adaptation, no "selective adjustment." All such theorizing is not based on any sound philosophic or scientific principle. It is of the same sort as any witch doctor employs. The supposed process or supposed fact of increasing adaptation is even assumed to be a novel manifestation in the universe, but the supposed "principle of selective adaptation" is not at all true and comes from a lack of a broad knowledge of living things and their phyletic relationships. Bacteria are adapted to survive and thrive through the geological ages as well as dandelions. Amoebas are just as well adapted as men. The fitness of their "adaptation" has nothing to do with their real taxonomic differences.

Returning to the characteristics of roots, we find that their textures are as extremely diverse in the same soil environment as are their colors. A few of the typical dry prairie roots are as follows: *Amorpha canescens* Pursh has exceedingly strong, tough roots. *Morongia uncinata* (Willd.) Britt. has such very brittle roots that they break as readily as sticks of candy. These two deep-rooted plants are often seen growing in the same prairie soil within a foot of each other. To speak of the toughness and brittleness as "adaptations" or the survivals of a "selective adaptation" is the height of foolishness. Other roots have all sorts and conditions of texture in the same soil. There are also all sorts of flavors in these roots. Sometimes very odd "adaptations" are encountered, as in *Equisetum palustre* L., which usually grows in wet soil. It has elastic rhizomes that can be stretched to a considerable extent like rubber. This "adaptation" might be of decided advantage and use in case of an earthquake or landslide! *Raphanus sativus* L. of our gardens has a thick, crisp, fleshy root. The rhizome of *Distichlis spicata* (L.) Greene is hard and rigid not because it grows in saline or alkaline soil, since the same type of rhizome may be found in soils of entirely different character, but simply because such "adaptations" are of no importance to the plant. It could thrive in the same habitat if it had an

entirely different "adaptation." It might be brittle or fleshy for example.

Variously Colored Twigs.—The color of twigs runs through about the same series as that of the roots. One can find almost any general color desired and there are also many ornamental patterns of streaks, blotches, mottlings and speckles. *Euonymus atropurpureus* Jacq. has green twigs. *Cornus stolonifera* Mx. has bright reddish-purple twigs. *Salix lucida* Muhl. has yellowish-brown twigs. *Ulmus americana* L. has brown twigs. In *Cercis canadensis* L. the twigs are dark reddish-brown and speckled. In *Gymnocladus dioica* (L.) Koch. the twigs are mottled white and purplish-brown. In *Amygdalus persica* L. the twigs are red above and green beneath. *Fraxinus americana* L. has dark gray twigs. The twigs of some woody plants and the stems of many herbaceous plants with inconspicuous flowers are striped. *Acer pennsylvanicum* L. has green twigs striped with darker lines. As a general rule the color of twigs is less brilliant than that of roots. This is probably due largely to the difference in the character of the epidermis and cuticle as commonly developed in the two systems. As in the case of the colored roots, to attempt to give a utilitarian explanation to the diversity of color tints of twigs would be extremely irrational, because no such utility is in evidence. These woody twigs grow in the same air and light and are subject to the same heat and cold, to the same dryness and moisture. Leaves have a more pronounced development of color and color patterns, with spots, streaks, and mottlings, than do roots or twigs, and those markings again can have no special utilitarian import. Only a mind of the most extreme credulity or perverted philosophic outlook could conceive of such a relationship.

Color of Plant Juices.—In many plants there are distinctive saps and juices of various chemical composition and these, as would be expected, are also of various colors. Very commonly the juice is colorless although it may have various chemical compounds. *Dicrophyllum marginatum* (Pursh) K. & G. and an endless array of species, genera, and families of plants have white juice, commonly called milky sap or juice. *Chelidonium majus* L. has saffron-colored juice. *Argemone intermedia* Sw. has bright yellow juice. *Sanguinaria canadensis* L. has red-orange juice. *Amorpha canescens* Pursh has bright coral-red juice, which is especially abundant in the young herbaceous

shoots before they become woody. Some species of Boletus, a genus of the Agaricales, have a juice which develops a clear blue color when the plant is broken. To claim that the yellow color of surplur, the white color of common salt, the blue color of sulphate of copper, and the green color of sulphate of iron are caused by "selective adaptation" would be rather foolish; to think that the colors of these plant juices must in some way be the result of "the selective adaptation principle" is equally so and the same observation applies to specific colors on the outside of the plant or animal. But the realms of fancy are infinite and the credulity of natural selectionists is boundless.

Any one studying the taxonomic system carefully will soon find that there is no general correspondence between the system on which we postulate relationships of groups and the so-called adaptations. There are adaptations to various conditions, as to cold, light, dryness, moisture, water, etc., but these do not run parallel with the taxonomic characters. They have little to do with the real fundamental problem of evolution. There is still no evidence whatever for the inheritance of characters acquired through response to environment and even if there were it would be of little consequence in the real problem of evolution. Since there is no direct correspondence between the environment and the taxonomic segregations and series, the hypothesis of either selective adaptation or of adaptation as a response of the individual to the environment is not tenable as an evolutionary causative agent or principle, but is rather the product of minds blindly reacting to an anarchistic belief as to the nature of the universe about us.

Recently, confusion has been introduced between the ideas of "natural selection" and selective elimination. We may have selective elimination whenever an evolutionary movement is proceeding in the presence of an exceedingly adverse environment, but usually the broader more fundamental taxonomic movements are not of such a nature as to produce an eliminative struggle. A lycopod without flowers succeeds in the same environment as one with flowers. A composite with the flowers in heads is just as much adapted to a dry prairie condition and no more so than a legume whose flowers are in a raceme. The epigynous composites or evening-primroses are no better fitted for a dry prairie environment than are hypogynous anemones and poppy-mallows. They all grow side by side. The special "adaptations" are the result of

internal causes as well as are the more fundamental characters which make up the taxonomic system. The "adaptations" are sometimes of use to the individual, but just as frequently they are of no use whatever or they may even be a decided detriment. The evolution proceeds in a given direction not because the environment is producing the change, but because the environment permits the orthogenetic movement to proceed in the given direction. The so-called "principle of selective adaptation" is a delusion, a figment of the imagination, and is contradicted by all the more fundamental evolutionary sequences plainly indicated in any study of the taxonomic system in relation to the environment.

The Action of the Living Cell.

Dr. Fenton B. Turck, whose death occurred a few months before the publication of this book, was a well-known surgeon in Chicago and New York. Over a long period of years he made many contributions to medical literature, many of them being concerned with the problem of surgical shock. As a result of this work he developed his theory of a **cytost**, or shock-toxin, a substance supposedly liberated from cells after their injury or death, affecting the activities of other cells of the body, and, if in sufficient amount, directly or indirectly causing the characteristic symptoms of traumatic shock. In his later years, Dr. Turck carried on considerable experimental work, first in the effort to test his theory, and later with the aim of learning more about cytost and its mode of action. The present book is not only a re-statement of the cytost theory and an account of the author's observations and experiments, but represents also an attempt to interpret these in terms of general cell physiology.

It is only fair to say that the majority of surgeons still regard the cytost theory as unproven. A considerable amount of experimental work by a number of competent investigators seems to indicate that the loss of blood and fluid from the body tissues, which in general accompanies or follows traumatic injury, is not a secondary effect, but is the primary cause of traumatic shock. If these results are substantiated, it will obviously not be necessary to postulate a special shock-toxin to account for most shock phenomena. However, many of Dr. Turck's later experimental results, as described in the present volume, are definitely irreconcilable with this alternative interpretation. The general concept of a cell-product stimulating or depressing the activities of other cells is, of course, firmly established today as a physiological principle. A few investigators, working independently, have also found some evidence (in Bacteria and Protozoa) for a depressing effect exerted upon living cells by products formed through the death and disintegration of other cells. In view of these facts, it is to be hoped that Dr. Turck's later experiments will be carefully repeated in detail by other investigators, and that this important field will be thoroughly explored.

W. J. Kostir.

The Action of the Living Cell. Experimental Researches in Biology. By Fenton B. Turck. xi+308 pp. New York, The Macmillan Company, 1933. $3.50.

TWO NEW SPECIES OF EARTHWORMS FOR OHIO.

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The author in 1928 listed twenty-two species of earthworms for the State of Ohio. The present paper includes additions to the list previously recorded.

Diplocardia verrucosa Ude, 1895.

This species was first described from specimens collected at Omaha, Nebraska. Frank Smith (1915) states that they are abundant in the soil of bottom-land forests of Illinois and Kaskaskia Rivers.

Length, 7–15 cm. Number of somites, 100–125. Color of anterior dorsal surface pale flesh. Setae widely separated. Clitellum saddle-shaped, situated on somites 13–18, inclusive. Prostate pores on 19, 21. Spermiducal pores in somites 20 and the spermathecal pores in somites 8 and 9. Sperm sacs in 9 and 12.

Only one specimen was collected by the author along the shore of Lake St. Marys in September, 1932.

Helodrilus octaedrus Savigny, 1826.

Known from various parts of Europe, Northern Asia, Iceland and Greenland. In North America it has been reported from Newfoundland and Mexico. Smith (1928) states that this species has been collected from Colorado and Illinois.

Length, 2.5–4 cm. Number of somites, 80–95. Color brownish-violet. Prostomium, epilobic. Clitellum on 28, 29–33. First dorsal pore on 4–5. The spermiducal pores on 15, between b and c. Oviducal pores on 9–10–11–12, in the setae line d. Septal sperm sacs in 9, 11 and 12. Spermathecae usually in 9, 10 and 11. Septal intervals aa, ab,bc, cd, approximately equal; dd somewhat greater than either.

In June, 1929, two specimens were collected near Akron, Ohio. They were found along the bank of the old canal.

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KEY TO THE EARTHWORMS OF OHIO.

Clitellum	Tubercula pubertatis	Prostate pores	Spermiducal pores	Spermathecal pores	Sperm sacs	Setae	No. of Somites	Length cm.	Color (antero-dorsal)	Name
13–18 sad.		18, 20	19	7/8, 8/9	9, 12	Wide	135–160	20–27	Brown	*Diplocardia riparia*
13–18 sad.		18, 20	19	6/7, 7/8, 8/9	9, 12	Wide	125–160	18–30	Pale	*Diplocardia communis*
13–18 cing.		18, 20	19	6/7, 7/8, 8/9	9, 12	Wide	90–120	4–12	Pale	*Diplocardia singularis*
13–18 sad.		19, 21	20	8, 9	9, 12	Wide	100–125	7–15	Pale	*Diplocardia verrucosa*
15–25		23, 26	19	6/7, 7/8, 8/9	11, 12	Close	165–225	15–20	Pink with blue irridescence	*Sparganophilus eiseni*
22, 23–26, 27	23–25, 26		13	9/10, 10/11 dorsal	9, 12	Close	80–100	4–6	Brown	*Helodrilus tetraedrus* f. *typica*
22, 23–27	23–25, 26		15	9/10, 10/11 dorsal	9–12	Close	80–100	4–6	Brown	*H. tetraedrus* f. *hercynius*
22–29	27, 28		15	None	11, 12	Close	40–60	2–5	Reddish-brown	*H. tumidus*
22–29 or 1/3 30	None		15	None	11, 12	Close	100–110	4–7	Brown-red	*H. gieseleri* var. *hempeli*
24–30	25, 26–29, 30 (indefinite)		15	None	11, 12	Close	90–100	3–4	Brown-red	*H. parvus*
24, 25–31, 32	24, 25–30 (indefinite)		15	None	11, 12	Close	70–100	2–6	Reddish-brown	*H. beddardi*
23, 24–33	None		15	None	11, 12	Close	100–130	7–10	Rose-red	*H. longicinctus*
24, 25, 26–31, 32 or 33	29, 30–31		15	9/10, 10/11	9–12	Close	130–150	4–8	Pale-red	*H. roseus*
24, 25 or 26–32	28–30, 31		15	9/10, 10/11	9–12	Close	75–125	5–15	Brown and buff (bands)	*H. foetidus*
25, 26–31, 32	28–30		15	9/10, 10/11	9, 11, 12	Wide	60–125	5–8	Red	*H. subrubicundus*
26–31	29, 30 (indistinct)		15	None	11, 12	Wide	90–110	4–8	Red	*H. tenuis*
27–34, 35	31, 33		15	9/10, 10/11	9–12	Close	100–250	5–20	Rose-red	*H. caliginosus* f. *typica*
27–34, 35	31–33		15	9/10, 10/11	9–12	Close	100–250	5–20	Rose-red	*H. f. trapezoides*
27–37	None		15	None	11, 12	Close	110–140	10–12	Chestnut-brown (purplish)	*H. zeteki*
28, 29–33	31–33		15	9/10–11/12d	9, 11, 12	Sep.	80–95	2.5–4	Brownish-violet	*H. octaedrus*
27–32	28–31		15	9/10, 10/11	9, 11, 12	Close	90–145	7–13	Reddish-brown (violet)	*Lumbricus rubellus*
29–37	31, 33, 35		15	9/9, 10/11	9–12	Close	80–125	5–7	Greenish	*H. chloroticus*
30–35	31–34		15	9/10, 10/11	9–12	Wide	100–170	5–16	Pale-pink	*Octolasium lacteum*

APPARATUS FOR THE MAINTENANCE OF CONSTANT TEMPERATURE AND HUMIDITY.

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The exacting demands for accuracy in modern biological research make necessary precise control of temperature and humidity. This paper is intended to set forth certain considerations which enter into the construction and operation of thermostats and humidostats.

AIR THERMOSTATS.

The physical properties of air must be borne in mind in order to be successful in maintaining it as a thermally static system. Salient characteristics of air are its low specific heat, or thermal capacity, and low thermal conductivity. A volume of air contains only one three-thousandth as many calories of heat as a similar volume of water. Hence in a given volume, a small loss or gain of heat produces a relatively great change in its temperature. Conversely, an object surrounded by air of different temperature will be affected very slowly because the air contains such a relatively small amount of energy to impart to the object. So it is that air is such an excellent insulator. For these reasons an air bath needs no elaborate insulation, and it is desirable to use heaters of small size. Moreover, a quick-responding thermoregulator is necessary.

Cabinets in which temperatures are to be held constant do not need to be elaborate or expensive. The success of accurate control depends more upon the perfection of the controlling instruments than upon excess insulation. A double-walled cabinet made of some insulating fiber board such as "Masonite" or "Cellotex," nailed to a light but rigid framework of wood, will give ample insulation for all but extreme temperatures. Dead air spaces of about two centimeters should be provided between layers of insulation. The case should be of air-tight construction.

Long low cabinets are the most practical. Such design gives better air circulation and more floor space. Since ento-

mological experiments are usually carried on in rather small containers, a greater efficiency is enjoyed where there is more floor area and less waste space at the top of the cabinet. A cabinet of good dimensions is 65 to 70 centimeters high, 80 centimeters deep, and as long as desired—perhaps 1.7 to 2 meters. Doors should be wide enough to accommodate good sized trays; moreover, one can work more effectively through an opening which provides ample elbow room. It is a good plan to hinge the door at the bottom to provide a work shelf when it is open. Doors without glass are lighter and more easily made. Observation windows may be built above the doors, thus giving the operator clear vision through the window while working with his hands through the door. Interior illumination is very helpful. A cabinet is more convenient if its floor is on a level with the worker's elbows. The floor should be of some material that is easily washed.

A rapid circulation of air in the cabinet is essential for uniform temperature. A small house fan may be set inside the chamber, or a larger slow-speed motor may be mounted on the outside and belted to a shaft running through the cabinet wall. But such a shaft is difficult to construct, and must be provided with good metal bearings to be free from vibration. A false inner back in the cabinet will form a duct to provide for the return of air to the heating units and fan. One adjustable opening, 15 centimeters in diameter, in the wall behind the fan, is sufficient for a fresh air supply. If an inside fan is used, an adequate cooling system should be provided to offset the heat generated by the motor. It is a good plan to construct a flue, opening through the bottom and top of the cabinet and enclosing the motor of the fan. Convection currents will carry out this troublesome extra heat.

All cabinets should be built to allow maintenance of a constant humidity. From the experience of Richardson, it seems unnecessary to line the cabinet with sheet metal or glass. The walls may be successfully waterproofed with two coats of priming shellac or lead paint, a coat of under-varnish, and two coats of the best waterproof spar; or three coats of "Duco" may be used.

The type of heating unit depends upon the temperature to be maintained. When only a small amount of heat is necessary it is common practice to use electric light bulbs. They are not efficient heaters because they consume more current per calory

of heat delivered than any other type of heater, and consequently overburden the thermoregulator or relay contact points. The points are then much more apt to stick and fail to turn off the heat. The old-fashioned electric room heaters, known as "Luminous Radiator Units," are very satisfactory heaters. They have a large heating surface and very low lag in heat delivery. These factors are vitally important in air conditioning. If such bulbs cannot be obtained, good heaters can be made of bare resistance wire wound on porcelain rods or asbestos. The flat resistance wire used in flat-irons is good. As a matter of fact, an electric heater, with more resistance wire added to reduce the wattage, makes an admirable heater for a high temperature air bath.

To be independent of surrounding temperatures a thermostat must have a cooling system such as cold water flowing through a metal tube. The flow of water may be adjusted so that the heater is off and on for equal periods. A more nearly constant temperature is obtained when the intervals of heating and cooling are short.

In certain situations gas heat might prove superior to electric. A very simple and not inefficient mercury thermoregulator to control the flow of gas to a burner can be purchased or made of glass tubing as illustrated.

WATER BATHS.

Maintenance of constant temperatures in liquid systems is in some ways much easier than in gaseous ones. The calorie content of water per volume is so very much greater than that of air that the heat interchange by conduction between water and the surrounding air is small. Hence careful insulation of the waterbath is not at all necessary. In case of a metal water container, insulation such as one layer of fiber board or an inch-thick layer of newspaper is sufficient. Such a tank will allow maintenance of temperature to within 0.01° C. On the other hand, considerable heat is lost as a result of evaporation from an exposed water surface. The evaporation rate varies with the weather and any draft that may blow. A tight cover over the bath will eliminate this cause of temperature fluctuations. Or if more practical, the water surface may be protected with an inch-layer of pure white oil which will both insulate and stop evaporation.

A good waterbath may be constructed from any one of the many types of non-rusting water containers. Glass aquaria are often desirable if the experiment must be inspected closely. Usually they need no additional insulation. One of the most serviceable types of container is the wooden barrel or hogshead. Barrels are cheap and readily obtained, and they lend themselves to all manner of carpentry for installation of instruments, water pipes, etc. No additional insulation is needed.

Rapid agitation of the water is of cardinal importance for accurate temperature regulation. A small propeller working in a vertical brass tube, so that a down current of water is created within the tube, is an efficient stirrer for a small bath. A heater of the knife-blade type can be placed in the tube and thus insure a rapid distribution of the heated water. Such a stirrer may be connected directly to a small motor, but it is usually more convenient to belt it to a motor located elsewhere. For a larger body of water a good agitator may be made from a piece of heavy sheet brass cut and bent like a boat propeller. This may be fastened to a horizontal shaft passing through the side of the tank and belted to a motor. A surface agitator of the centrifugal type can be fashioned from a vacuum sweeper. The discharge opening should be cut away so that the water will surge out on the same plane in which the fan turns, and the fan blades trimmed down somewhat. It is necessary to connect a large rheostat in series with such a motor to reduce the speed.

Most immersion water heaters on the market are serviceable. The "Luminous Radiator Units" are excellent water heaters. There should be no appreciable lag in heat delivery, but the heating surface presented to the water is not so important if good circulation occurs. A cooling system is a necessity for close temperature regulation.

It is sometimes convenient to pipe water of uniform temperature from the water bath to the instruments or animal chambers than to immerse them in the main body of water. A small brass centrifugal pump taken from a truck engine circulates water through such an outside circuit in the author's laboratory.

THERMOREGULATORS.

Ordinary thermoregulators depend on expansion as the acting force. Hence the coefficient of expansion and thermal conductivity of a substance determine its usefulness as a

thermoregulator medium. Gasses show the greatest volumetric reaction to temperature changes and are most sensitive in effect. However, the great changes in volume of gas produced by fluctuations of barometric pressure obviate the possibility of causing a gas filled thermoregulator to maintain a given temperature. Gas filled wafers are sometimes used in incubators, but they do not give dependable control.

Liquids display a lower coefficient of expansion, but the rate of thermal conductivity is about twenty times as great for liquids as gasses. Fluids offer the most practical solution to the problem of precise temperature control. Metals have a much lower coefficient of expansion than liquids, but they have a high rate of thermal conductivity. In spite of their low sensitivity metals are most frequently used as the agent in thermoregulating devices because a metallic regulator can be built to handle 110-volt current without a relay.

Metallic Thermoregulators.—Of the metallic thermoregulators, the DeKhotinsky type seems to be the most satisfactory. It is made of a metal helix whose torque opens and closes contact points with changes in temperature. They are especially dependable when provided with twin contact points, and under favorable conditions will regulate the temperature to within 0.5° C. Bimetallic or metal-nonmetal regulators will usually keep the temperature to within 1° or 2° C. of that desired, but they are inferior and not overly dependable.

Most metallic thermoregulators are designed to make and break a 110-volt circuit directly without the aid of a relay. The burden thus placed on the breaker points is severe. Only metals having the highest melting points will resist the intense heat of the tiny electric arcs which are produced each time the circuit is broken. If the contact points are broad, the arcs will be diffused over the surface and will be less apt to melt out minute pockets or fuse the points together. Rough contact surfaces cannot meet exactly flush and so they foster arcing and sticking. Contact points are highly polished when manufactured because the reliability of the instrument depends on the mirror surface of the points. Therefore the points should be given good care, and never scraped with a file or knife. If the surfaces become dirty, impregnate soft paper with Jewelers rouge (Ferric Oxide powder) and draw it several times between the points. If they have become pitted so that rouge is insufficient, use the finest emery dust on soft paper or

No. 0000 emery cloth. Finish with a prolonged polishing with rouge, and adjust so that the points make contact over their entire surface. Emergency contact points may be made out of small discs of coin silver highly polished.

It is important to guard against overloading the thermoregulator. As small heating units as possible should be used, and if their combined power consumption is more than 200 watts it is better to split the circuit. When most of the load burns continuously and only a small fraction is in series with the regulator it will adjust the temperature much more accurately.

Liquid Thermoregulators.—For the maintenance of temperatures within a range of less than 0.5° C., it becomes necessary to use liquid as the regulator medium.

The sensitivity of a thermoregulator fluid is determined by the relationship of the specific heat, density, and coefficient of expansion of the thermoregulator fluid, to the specific heat and density of the substance whose temperature is regulated. In other words, the calorie content per volume of the bath medium should be greater than that of the thermoregulator liquid. Such a relationship exists between water and mercury or organic fluids. It seems both in theory and practice that a well designed mercury thermoregulator is not excelled for water baths.

The case of air conditioning is quite different. The calorific ratio is reversed so that air contains much less heat per volume than the regulator liquid. The temperature of the air can change considerably before sufficient energy is transferred to alter the temperature and volume of the liquid. This time factor is apparently responsible for the difficulties encountered in maintaining temperatures in an air bath within less than half a degree. In order to offset this condition it is of unquestioned value to employ an organic fluid in order to benefit by the higher coefficient of expansion (about ten times that of mercury).

Electric Thermoregulators.—Rarely and for the most exact temperature regulation, thermoregulators have been built to make use of the changing resistance of a band of metal, or changing potential of a thermocouple. Such slight electrical variations are recorded by a sensitive galvanometer. A small light beam is reflected from the galvanometer mirror to a light-sensitive cell some distance away. When the temperature rises, the mirror deflects the light beam onto the cell, activating

it to pass a small electric current. This current is amplified in a vacuum tube relay so that it will operate a magnetic relay which breaks the heating circuit. Although complicated, this method has been reported successful in holding temperatures in a very small bath to plus or minus one one-thousandth degree.

Mercury Thermoregulators.—Mercury filled thermoregulators are so frequently used that almost every laboratory has its own design of instrument. Most of them are good, but the one described here is superior in simplicity and ease of construction. It can be quickly made by a person unfamiliar with glass blowing.

A large tube, with bulbous end or not, is slightly flared at the top by heating and spreading with a metal triangle or carbon rod. This tube should hold about one kilogram of mercury. A second piece of glass tubing which will fit snugly into the first is cut about 10 cm. long, and enlarged at one end to form a cup. This may be accomplished by heating and working a hot carbon rod into the bore to swell the tube. A piece of 2 mm. capillary tubing, 5 cm. long is flared very slightly at both ends so that it will just slip into the neck of the second tube. The capillary is coated on both ends with soft DeKhotinsky's cement or "lac-wax,"* preparatory to sealing in the second tube. A copper wire to make fixed contact with the mercury is laid along the side of the capillary and inserted along with it into the neck of the second tube. A gentle warming will melt the wax and seal both capillary and wire in place. This assembly is then inserted in the neck of the mercury reservoir and sealed in place with wax or plaster of Paris. A metal bracket is fastened about the top of the regulator to support the contact wire which extends into the capillary tube. Either a screw or sliding clamp makes a fine adjustment of this wire possible. Platinum wire should be used for the tip of the electrode, since it does not amalgamate with mercury. It may be joined to a copper wire by first welding to constantan wire in a blast lamp and then soldering the latter to copper. Platinum is exceedingly difficult to solder. A temporary joint may be made by cleaning both wires and winding two or three

*"Lac wax" is a convenient sealing compound made of flake orange shellac and pine tar in proportions according to the hardness desired. It is not resistant to strong chemicals, but is more easily handled and much cheaper than DeKhotinsky's cement.

turns of the copper wire about the platinum, then mashing them together and covering the union with sealing wax.

Organic Liquid Thermoregulators.—Toluol is often recommended as a thermoregulator liquid. The author has found carbon tetrachloride much superior except for temperatures above 70° C. Carbon tetrachloride has a slightly higher coefficient of expansion, greater density, is non-inflammable and is cheaper and more easily obtained. Methyl Alcohol is another good regulator fluid for biological work.

A section of unused automobile radiator-core, which holds about two liters, is used as the reservoir for the regulator fluid. Such a container exposes the liquid to a maximum surface per unit volume, insuring a rapid response to the temperature fluctuations of the air. The section of radiator is converted into a tight container by soldering suitable covers over the two ends where openings are exposed. Two copper tubes are soldered into opposite ends of the top. One is short and serves to permit the escape of air during filling; when the container is full and all air excluded this tube is pinched shut and soldered The other tube leads to the glass manometer in which a small droplet of mercury makes and breaks contact with a platinum wire. In order to prevent carbon tetrachloride from dissolving the stop-cock grease and leaking out, or evaporating from the open reservoir, it is necessary to provide for a trap liquid to seal it in the reservoir. A small brass trap chamber, where carbon tetrachloride and water meet, is soldered to the second tube leading from the reservoir. This trap prevents water being drawn into the radiator or carbon tetrachloride coming in contact with the stop-cock. A "T" tube is attached to the trap, one arm of which connects with a stop-cock and filling reservoir, and the other to the glass manometer. The manometer is made of 2 mm. capillary tubing. In the rear arm a small bulb is blown to serve as a trap to prevent mercury from being drawn into the metal part of the instrument. (Mercury will amalgamate with and dissolve soldered joints.) A copper wire is inserted through the rear arm of the glass "U" tube to make contact with the mercury. The manometer tube is cemented to the copper tube with wax, through which joint the contact wire protrudes. To fill the instrument carbon tetrachloride is poured through the filling reservoir until the instrument is entirely full and overflowing at the overflow tube. Then sufficient water is poured in to half fill the trap chamber

At this juncture the overflow tube is pinched together and soldered. Next a droplet of mercury, large enough to fill the "U" manometer up to its trap is introduced through the open end. Finally a rubber tube is slipped over the free arm of the manometer and water run past the mercury in its trap until all air has been expelled from the connecting tubes and filling reservoir. The mercury drops back into place as soon as water ceases to flow past. The excess water can then be removed and a platinum electrode inserted into the free arm.

The adjustment of this thermoregulator to any desired temperature is quick and easy. When the stop-cock is open, the mercury in the "U" tube will stand at a certain level. The platinum electrode is set very close to the mercury meniscus. The air bath is then heated to the temperature desired and the stop-cock closed. The regulator will then hold the temperature at that point.

Mercury displays considerable adhesion to glass. Therefore, any movable column of mercury tends to stick to the glass with the result that the mercury meniscus is often greatly distorted or movement actually delayed. A lubricant consisting of a 5% solution of Phenylhydrazine Base in dibutyl phthalate will effectively prevent such difficulty.

MOVING CONTACT MECHANISM.

When more exact temperature regulation is desired than an ordinary mercury or carbon-tetrachloride regulator will afford, a device may be installed which will greatly increase the sensitivity of either of these types. Any sort of a mechanism will serve which will continuously lift and lower the platinum contact wire in the capillary tube a distance of one to three millimeters. A frequency of 40 to 60 times a minute is best.

In the case of any fixed contact regulator, there is always a lag in operation behind the temperature of the bath. The bath is overheated before the regulator turns off the heating current and overcooled before contact is made again. Furthermore, the longer the periods of heating and cooling are, the more irregular will be the curve of temperature. When a moving contact is used the alternations of heating and cooling are so rapid that lag in operation is circumvented. Also the temperature curve will be reduced to a nearly straight line. Usually there is no possibility of graduating the amount of heat supplied to a bath—either the heater delivers maximum heat or none.

If a moving electrode is used it produces the effect of a graded temperature change, for when the mercury rises slightly the needle is immersed for a longer fraction of each stroke and the heater therefore delivers a slightly smaller amount of heat per minute. Yet it does not let the bath cool rapidly as though it were entirely shut off. Such a delicate tempering of heating and cooling makes possible most exact temperature control.

Besides these, there are other advantages which make an interrupter-regulator more dependable. There is a positive mechanical rupturing of the mercury meniscus, so that the oxide film can never retard or prevent contact being made at the proper instant. Also, the constant agitation of the meniscus keeps it in a more regular form.

Any device which operates smoothly in lifting and lowering the contact wire is adaptable. The author uses a water motor made from a two-ounce salve box. A disc of thin brass is incised from the edge and the sectors turned 90° to make the paddle wheel. The bearings through which the brass axle protrudes are merely pieces of copper tubing soldered to the lid and bottom. The intake is soldered obliquely through the side of the box, with an outlet more than twice as large on the opposite side. A midget pulley with a cam to move the contact wire is belted to the axle of the water motor with a rubber band. A more elegant mechanism is an electric windshield wiper with slightly altered gears. A storage battery supplies current.

The Physiology of Farm Animals.

This book fills a long vacant niche in the literature pertaining to the physiology and nutrition of farm livestock. It was originally planned that this work should appear in two volumes, the first as an application of the general principles of physiology to farm animals, and the second, a volume dealing with animal nutrition. The first volume, by Marshall, was published in 1920 and is now out of print. The publishing of the second volume was abandoned following the death of Professor Wood, the senior author.

The Physiology of Farm Animals, by Marshall and Halnan, is the result of a thorough revision of the first volume, plus the addition of the material originally intended for the volume on nutrition. Therefore, this book includes a wealth of subject material of value to students of agriculture, especially those interested in farm animals and poultry.

The book is well written and amply illustrated. It should find ready acceptance as a textbook or reference for elementary courses in physiology as applied to farm animals.

EDWIN E. HEIZER.

Physiology of Farm Animals, by F. H. Marshall and E. T. Halnan. 366 pp., 118 ill. Cambridge, The University Press; New York, the MacMillan Company, 1932. $3.25.

ADDITIONS TO THE OHIO LIST OF ROBBER FLIES.

(DIPTERA: ASILIDAE.)

STANLEY W. BROMLEY.

Since the appearance of my "Preliminary List of the Robber Flies of Ohio," (Ohio State Museum Science Bulletin, Vol. I, No. 2, November 1, 1931), the assiduous collecting of Mr. E. S. Thomas, Curator of Natural History, and Mr. Charles F. Walker, Assistant Curator, has brought to light five additional species hitherto unrecorded from the state. Three of these were not in the hypothetical list. The total number for the state now stands at 70 species.

66. *Leptogaster incisuralis* Loew. Franklin County, ("Red Hills"), September 2, 1932. (C. F. Walker.) At light. Three specimens.
67. *Bombomima champlainii* Walton. Flat Rocks, Lancaster, July 1, 1931. (E. S. Thomas.) One specimen.
68. *Mallophora clausicella* Macquart. Lynx, Adams County, July 30, 31, 1932. (E. S. Thomas and C. F. Walker.) Seven specimens. Fairfield County, Berne Township, August 14, 1932. (C. F. Walker.)
69. *Asilus angustipennis* Hine. Washington Township, Jackson County, August 30, 1931. (E. S. Thomas.) One specimen. A very rare species.
70. *Asilus prairiensis* Tucker. Higby, Ross County (on prairie). June 20, 1931. (C. F. Walker.) One specimen.

In addition, specimens of *Promachus hinei* Bromley (Annals Ent. Soc. America, XXIV, 2, 435, 1931) were collected near the type locality (West Jefferson), at Newport, Madison County, September 5, 1931 (E. S. Thomas), and Franklin County, Big Darby, September 12, 1931 (E. S. Thomas). One of these, a male, at Newport, was taken with the yellow-jacket (*Vespa maculifrons*) as prey.

The Development of Genetic Characters.

This is one of the most valuable and important biological books of recent years. Recognizing the opposition of the fundamental concepts of genetics and those of experimental embryology in regard to the nature and development of the organism, the author attempts a reconciliation of these views. The facts of experimental embryology are clearly and logically set forth, and their contribution to the development of adult characteristics carefully evaluated. It is essential that all zoologists have access to a copy of this clear analysis of developmental problems.—L. H. S.

Experimental Analysis of Development, by B. Dürken; translated by H. G. and A. M. Newth. 288 pp. New York, W. W. Norton & Co., 1932.

NOTES ON A COLLECTION OF MYXOMYCETES FROM SOUTHEASTERN MICHIGAN.*

FLOYD B. CHAPMAN,
Ohio State University.

During the autumn of 1932, Mr. Clarence E. Taft, of the Department of Botany, Ohio State University, made a trip through southeastern Michigan, visiting portions of Macomb and Lapeer Counties. Although interested primarily in the collection of algae, he was able to secure nearly a hundred specimens of Myxomycetes or slime molds. Since then it has been the writer's privilege to work over the collection, and this paper is the result. So far as the writer can ascertain, nothing has previously been published on the Myxomycetes of this section of Michigan.

The writer is indebted to Mr. Taft for the large number of specimens, and to Dr. W. G. Stover and Dr. G. W. Blaydes for helpful advice and criticism. Professor T. H. Macbride's "North American Slime Molds" has been followed throughout.

1. **Ceratiomyxa fruticulosa** (Muell.) Macbr. Collected once, in woods north of Noland Lake, Macomb County, Growing on rotted maple wood. Rather common everywhere, according to Mr. Taft's notes.

2. **Fuligo septica** (Linn.) Gmel. This common species was found several times in a woods north of Noland Lake. In most cases the aethalia had been reduced to tatters by weathering. The form *ovata*, with yellowish foamy crust, was the form most frequently collected. On oak.

3. **Didymium melanospermum** (Pers.) Macbr. This beautiful species, with snow white sporangia and short black stalks, was collected once from oak in a woods north of Noland Lake.

4. **Diderma floriforme** (Bull.) Pers. This species, common in the Central States, was found on well decayed oak, in the woods north of Noland Lake. When collected, the sporangia were "closed," but after a few hours, began to burst open, giving to them the customary flower-like appearance.

5. **Stemonitis fusca** (Roth.) Rost. The dusky sporangia of this species were found a number of times in Hamilton's woods, 4 miles northwest of Romeo, Macomb County. On wood of large-toothed aspen.

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*Papers from the Department of Botany, Ohio State University, No. 321.

6. **Stemonitis virginiensis** Rex. This is believed to be the fourth record for the species in North America. It was collected once from aspen, in Hamilton's woods, northwest of Romeo.

7. **Stemonitis splendens** Rost. Rather common on oak and maple in Lapeer County, 8 miles northwest of Romeo.

8. **Stemonitis smithii** Macbr. The tall, slender, cinnamon-brown sporangia were collected twice from aspen, in Hamilton's woods, 4 miles northwest of Romeo. The sporangia measure up to 7 mm. in height.

9. **Stemonitis herbatica** Peck. A large number of sporangia were found on oak, northwest of Romeo. These specimens are very dfferent from the usual *S. herbatica.* According to Dr. G. W. Martin, of the State University of Iowa, they have been parasitized by a species of *Hyphomyces.* The parasitic fungus completely changes the appearance of the sporangia, causing them to take on a dull black color. Upon examination the spores and capillitium are found to be compacted into a dense mass. This *Hyphomyces* must occur rather generally on *S. herbatica,* as the writer also possesses several parasitized specimens from Ohio.

10. **Cribraria aurantiaca** Schrader. Collected twice from oak in Lapeer County, 8 miles northwest of Romeo.

11. **Lycogala epidendrum** (Buxb.) Fries. This species is common on many kinds of deciduous trees in southeastern Michigan. Specimens were taken from oak in the Harris woods, northwest of Romeo, and from oak and maple in Lapeer County, 8 miles northwest of Romeo.

12. **Arcyria incarnata** Persoon. Rather common on oak in both Macomb and Lapeer Counties. Specimens were collected in a woods north of Noland Lake, in the Harris woods, 3 miles northwest of Romeo, and again in Lapeer County, 8 miles northwest of Romeo. The sporangia are very irregular in shape, departing from the usual cylindrical form. They are weak and procumbent, cling together, and are frequently fused. However, the general color of the sporangia and the characteristics of the capillitium, spores, and stalk serve to place these specimens under *A. incarnata,* Pers.

13. **Arcyria denudata** (Linn.) Sheldon. Undoubtedly the most abundant slime mold of southeastern Michigan. It is to be found everywhere on many kinds of wood. Specimens were found on elm and maple in woods northwest of Romeo, another woods north of Noland Lake, and again in southern Lapeer County. The species also occurred on yellow birch in a cedar swamp 2 miles west of Romeo, on white oak in a forest southwest of Romeo, and in another woods 4 miles southeast of Romeo.

14. **Hemitrichia vesparium** (Batsch.) Macbr. Very common on maple, oak, birch, and other deciduous trees. Sporangia in all stages of formation—the mature plasmodium, fully formed sporangia, and the empty sporangia which resemble miniature "wasp nests," were found. The species was collected from woods northwest and southwest of Romeo, and from southern Lapeer County.

15. **Hemitrichia clavata** (Pers.) Rost. Common to abundant in most of Macomb and Lapeer Counties. On many kinds of wood: oak, aspen, birch, and maple. Collections are from northwest and southwest of Romeo, and southern Lapeer County. Both newly formed and aged sporangia were found.

16. **Hemitrichia stipitata** (Mass.) Macbr. Collected twice; northwest and southwest of Romeo. On aspen and maple. The presence of a complete capillitial net without free ends serves to distinguish this species from *H. clavata*.

17. **Trichia contorta** (Ditm.) Rost. Listed by Macbride as "rare" in North America. A large number of sporangia were collected from a decayed aspen log, lying partially submerged in a pond. Hamilton's woods, 4 miles northwest of Romeo.

18. **Trichia scabra** Rost. Collected once from oak in Harris woods, northwest of Romeo.

19. **Trichia persimilis** Karst. Found once on white oak in woods northwest of Romeo.

20. **Trichia favoginea** (Batsch.) Pers. This beautiful species was taken from oak, northwest of Romeo.

21. **Oligonema flavidum** (Peck.) Mass. On aspen, in Hamilton's woods, northwest of Romeo.

22. **Oligonema nitens** (Lib.) Rost. Taken once in an oak-maple forest southwest of Romeo.

Many of the Myxomycetes listed above are typical autumn species, notably the *Trichias*, *Oligonema flavidum* and *O. nitens*, *Arcyria incarnata*, and *Diderma floriforme*.

On the basis of number of times collected, the most common Myxomycetes of southeastern Michigan would seem to be, in the order named: *Arcyria denudata*, *Hemitrichia vesparium*, *Hemitrichia clavata*, *Lycogala epidendrum*, *Fuligo septica*, *Arcyria incarnata*, and *Ceratiomyxa fruticulosa*.

Of the twenty-two species mentioned, about four or five are particularly noteworthy. *Didymium melanospermum* has seldom been collected in the Central States. This is true also of *Stemonitis virginiensis*, *Stemonitis smithii*, *Cribraria aurantiaca*, and *Trichia contorta*. The writer feels sure that the rich forests of Michigan will ultimately yield many times the number of species listed in this paper.

FLORA IN THE ROOF OF THE UPPER FREEPORT COAL AT CALLAHAN'S MINE, TEEGARDEN, OHIO.*

WILLARD BERRY.

Last spring several graduate students at Ohio State University collected several good specimens of plant fossils from the roof of Callahan's Mine, one mile north-west of Teegarden, Columbiana County, Ohio. These fossils were turned over to me and at my request the students revisited the Mine and in November one of the men, Mr. Sturgen, collected over 500 pounds of material. It is from this collection that the determinations have been made. As might be expected this method of collecting made for much duplication of forms but is compensated for in the abundance of material.

The coal mined at Callahan's Mine is the Upper Freeport which is at the top of the Allegheny series in the Upper Carboniferous or Pennsylvanian of the Paleozoic. The roof shale and the matrix of the impressions is a gray, slightly sandy, poorly bedded clay shale. There are small slickened blocks in some parts. In some instances there is considerable evidence of movement in the shale before complete compacting if we are to accept the irregular bending and curling of the plants. This curling could not be interpreted as curling due to dried material being inundated as there is no evidence of land conditions in the sediments; they appear to be water laid deposits. Also what bedding there is, is bent with the fossils. This condition was probably caused by eddies, or scour, or even something like tide riffs.

The flora as studied does not lend itself to correlation with other Upper Freeport horizons due to the lack of floral lists of this horizon. I expect to continue the study of this horizon and in time make a complete report on the Upper Freeport plants for the entire area in Ohio, in which report I will include illustrations of the plants.

In all there are at least 26 species, all previously reported from the Allegheny, comprising 7 genera and 5 families.

*Read before the Ohio Academy of Science, April 14, 1933.

The tentative list is as follows:

Pteridophyta.

Ficales.

Triphyllopteridae.

Pseudopecopteris (?) cf. *obtusiloba* (Brongn.). Lx. Rare.

Pecopterideae.

Pecopteris dentata Brongn.................Common.
P. pseudovestita D. White..................Common.
P. vestita Lx. (not previously reported from the upper Allegheny)..................Common.
P. arborenscens Brongn....................Fairly common.

Megalopterideae.

Neuropteris cf. *trichomanoides* Brongn.......Rare.
N. fimbriata Lx..........................Rare.
N. auriculata Brongn......................Fairly common.
N. inflata Lx.............................Fairly common.
N. Collinsii Lx...........................Fairly common.
N. Scheuchzeri Hoffm. (*N. hirsuta* Lx.), most abundant fossil.
N. Rogersi Lx............................Fairly common.
N. sp. A...............................Common.
N. sp. B...............................Fairly common.

Sphenophyllates.

Sphenophylleae.

Sphenophyllum cuneifolium (Stb.) Zeill.......Rare.
S. majus Brongn..........................Rare.

Lycopodiales.

Lepidondendreae.

Foliage.

Lepidodendron Brittsii Lx...............Rare.
L. lanceolatum Lx......................Rare.
L. rigens Lx...........................Not rare.
(Probably more abundant as small fragments.)

Stems.

L. sp. A..............................Rare.
L. sp. B..............................Rare.
Lepidostrobus variabilis L. & H. (may represent several sp.)..........Not rare.
Lepidophyllum lanceolatum Brongn.......Abundant.
L. majus Brongn.......................Rare.
L. ovatifolius Lx......................Common.
L. sp................................Rare.

THE GENUS AGELLUS, GEN. NOV.

(HOMOPTERA, CICADELLIDAE.)

DWIGHT M. DELONG AND RALPH H. DAVIDSON,
Ohio State University.

In a recent number of the Journal of Science, January, 1933, the writers discussed the genus *Eugnathodus* (p. 55). A new name was suggested and description offered for the species which Baker apparently had in mind when he described the Genus *Eugnathodus*. At that time it was thought desirable to let the genus name stand if possible to prevent confusion in literature. But further study and consideration has revealed the fact that according to opinions 14 and 65 of the international code of Zoological Nomenclature, *E. abdominalis* V. D., must remain the type of the genus Eugnathodus since definite specimens were not designated although undoubtedly used.* *Eugnathodus* Baker consequently must be made a synonym of *Balclutha* Kirk and the name *Agellus* is here proposed for the genus previously designated *Eugnathodus* and which was described briefly in the paper cited above.

It is closely allied to *Balclutha*, but differs in the following respects: Vertex more broadly rounded and scarcely produced before the anterior margins of the eyes and anterior and posterior margins almost parallel, head slightly broader than pronotum, lateral posterior angles of pronotum not wider than vertex. General venation as in *Balclutha* with inner sector of elytra not forked, two ante-apical cells being produced. Oedagus of internal genitalia with dorsal, basal, protruding processes. In *Balclutha* the basal portion is enlarged and may extend dorsally but without finger processes.

Type of genus *Agellus neglecta* DeL. and Dav.

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*This has recently been verified by P. W. Oman, Taxonomic Division, U. S. Bureau of Entomology, National Museum.

BOOK NOTICES.

Modern Alchemy.

There is a certain sentimental, yet pardonable, pride which we all feel in the family succession in the stage, law, business and even in science. This father and son joint contribution is something in which we may justly feel pride. The book is a review of modern developments in the field of chemistry. While a fundamental knowledge of chemistry is essential for the thorough understanding and appreciation of the book in its entirety, still, the average lay reader will find many enjoyable passages, and with a willingness to accept certain statements without going into the reasons for them should be able to appreciate the major portion of the book. A "popular" book in a scientific field must of necessity be either too complex or too elementary for many readers. The authors have attempted to follow an intermediate path which should appeal to both the professional scientist and the general reader. The book deals principally with the modern theoretical, rather than industrial, developments. Particular emphasis is placed on atomic structure and synthetic medicinals. A certain amount of emphasis is placed on the development and production of ideas and research from the University of Illinois, where the senior author was Director of the Chemical Laboratories for nearly a quarter of a century.

WALLACE R. BRODE.

Modern Alchemy, by W. A. NOYES AND W. A. NOYES, JR., 205 pp. Springfield, Charles C. Thomas, 1932.

The Triumph of Chemistry.

This is a popular book on a general theme of the importance of economic planning in chemistry. While the author discusses the rise and growth of chemistry in a historical sequence, he also takes numerous occasions to point out the influence of good and poor economic planning and to discuss the influence of the chemical industry on our present economic situations with regard to high tariff, farm relief, railroads, etc. The book is well written and, with the exception of two short chapters which the author suggests for a possible omission, the non-technical reader as well as the scientist should find the book to be well worth reading.

WALLACE R. BRODE.

Chemistry Triumphant, by WILLIAM J. HALE. 150 pp. Baltimore, Williams and Wilkins, 1932. (One of the Century of Progress Series.)

Fossils.

Those who have found Zittell's Textbook of Paleontology valuable will welcome this new revised edition of the second volume. The first edition in English was published in 1902, since that time much has been discovered and we are indebted to Dr. Smith Woodward for its inclusion in this new edition. The new edition contains 181 more pages and 180 additional illustrations, retaining, however, the same type of presentation and illustration that was preferred by Zittell. The classification has been carefully revised and is in keeping with the modern ideas on vertebrates. This volume covers from the earliest fish up to and including the birds.

W. BERRY.

Textbook of Paleontology (Zittell), translated by EASTMAN, revised by SIR ARTHUR S. WOODWARD. Vol. II, 464 pp. New York, The Macmillan Co., 1932.

Snakes and Kinkajous.

The well-known naturalist of the Bronx Park Zoo has added another to his books of adventure. Much of an informative nature is here, and many thrills and not a few laughs await the reader. The strictly scientific reader must close his eyes to many a teleological statement, such as, "A copperhead among dead leaves is a remarkable illustration of protective resemblance. The snake knows this, hence the quiet attitude of most copperheads and their lack of inclination to strike or bite, unless touched or stepped on," but there can be no questioning Dr. Ditmar's ability as a naturalist, nor his intense enthusiasm. The reader will share the thrills and enthusiasm to the fullest extent, and will emerge wiser in the ways of serpents and their poisons, not to mention other odd animals.

L. H. S.

Thrills of a Naturalist's Quest, by Raymond Ditmars. 268 pp. and 45 illustrations. New York, The Macmillan Co., 1932. $3.50.

Crystals.

This book, while designed primarily for students of petrology, will be of service to students of chemistry and physics and especially to ceramic and metallurgical engineers who need to have the fundamentals of crystallography clearly set forth in a readily understandable fashion.

The text contains the conventional material as to the nature, classification and physical properties of crystals, together with two chapters, one on the optical properties of minerals, and one on the methods of investigation of optical properties of bodies in general.

As stated in the preface the author has touched rather lightly the fundamental topic of crystal structure and unit lattice as being a topic beyond the ability and training of the average student of geology. It is confidently predicted that the next generation of geology students will insist that these ropics be amplified in future text-books of this sort.

The book is attractively edited, a thing that is true of anything the Cambridge Press turns out. It should find a ready sale among elementary students of the physical sciences, especially of mineralogy and geology.

F. C. Blake.

Form and Properties of Crystals, by A. B. Dale. 186 pp. New York, The Macmillan Co., 1933, (Cambridge, The University Press), $1.60.

Dissection of the Cat.

This manual of practical directions for the dissection of the cat and the study of its anatomy represents a revision of the directions for dissection which were formerly included in Reighard and Jennings' **Anatomy of the Cat,** but here published as a separate manual. It includes a discussion of essential literature on this subject, the preparation and use of specimens, and directions for laboratory dissection by the "System Plan," taken from the former volume. These have been revised by Dr. Elliott, of Ohio University, who has also added his directions for dissection by the "Regional Plan," traditionally used by teachers of human anatomy. Both methods are thus made available to the student within the compass of a single manual of convenient size for laboratory use. Many page references are given to descriptions of structures in Reighard and Jennings' Anatomy of the Cat which this manual is written to accompany. A useful chart, summarizing the nerve supply to important muscles of the body, and a large diagram of the nervous system is given in the appendix. This is recommended for its concise arrangement, and its ready adaptability to laboratory work.

John W. Price.

Dissection of the Cat, by Jacob Reighard and H. S. Jennings. Revised, with the addition of A Manual of Regional Dissection, by Rush Elliott, vi + 106 pp., New York, Henry Holt and Co., 1932.

The Foraminifera.

After some years of consideration the author has published his ideas on the classification of the Foraminifera. Of the roughly 1,100 generic names that have been published, he considers 542 of them to be valid. The rest of them are either brought into the "valid genera" or are discarded as being invalid, unrecognizable, **Nomina nuda**, or else as not being foraminifera at all. Throughout the entire classification the rules of Zoological Nomenclature are rigidly followed, which procedure, although excellent, leads to the finding of some forgotten names. In this classification the author recognizes 35 families as against 10 by M. S. Schultz (1854), 21 by A. E. Reuss (1861), 10 by H. B. Brady (1884), and 45 by Cushman (1928). The present classification in use, is mainly Cushman's in this country, and Brady's in Europe, with some using Cushman's. The genera are all illustrated and in most cases are after the type figure. The illustrations are all line cuts and quite clear, though as must be expected in a work of this kind, limited in number for each genus. There is a good glossary and index.

W. BERRY.

A Manual of the Foraminifera, by J. J. GALLOWAY. 481 pp. Bloomington, Indiana, The Principia Press, 1933.

Atoms.

The University of Pittsburgh Physics Staff have recently given us a rather delightful book, the purpose of which is to acquaint the beginner in natural science with much of that which is occupying the minds of present day physicists.

The book begins with a short introduction which in reality is a summary of the status of physics at the beginning of the century. This is followed by three chapters devoted to the corpuscular nature of matter, electricity, and radiation. The middle portion, comprising seven chapters may be said to be devoted to atomic and molecular structure, beginning with a survey of spectroscopic methods, containing many clear and instructive plates and diagrams. The interpretation of line spectra and x-ray spectra in terms of Bohr models and subsequent vector models is treated at some length and is followed by a discussion of crystal structure as revealed by x-ray experiments. The subject matter, **waves and corpuscles**, is obviously difficult to treat in so brief a space and in so elementary a fashion and to the writer it appears that this chapter lacks some of the desired clarity. It seems that a very elementary problem (say that of the simple rotator, discussed but not actually carried out in Chapter XI) might have been inserted as an example of Schrodinger's theory. Chapter XI is devoted to the topic of molecular structure and molecular spectra, and gives to the layman quite a vivid and clear representation of that field of endeavor. Here again, it is felt that the pseudo quantum mechanical treatment of the rotator as given is unsatisfactory and that a more compete treatment as earlier suggested is much to be preferred.

The remaining chapters are devoted to nuclear physics, relativity, astrophysics, and related topics, closing with five very helpful and valuable appendeces. A detail which ought not to go without commendation is the list of problems at the end of each chapter. The goal toward which the authors strive; namely, to place in the hands of the layman, reliable accounts of the teachings of physical science, is a most difficult one, and the writer feels that on the whole the authors are to be congratulated on their success. H. H. NIELSEN.

Atomic Physics, by members of the Physics Staff of the University of Pittsburgh. v + 335 pp. New York. John Wiley and Sons, 1933. $3.50.

Disease and Insects.

Here is a practical and readable book written for students interested in medical entomology and public health service. The author is a public health surgeon. The first two-thirds of the book are devoted to the various groups of arthropods, their anatomy, taxonomy, life history, and control. There are many

workable keys, some good diagrammatic figures, and a few notes on technique. A discussion of a dozen or so diseases carried by arthropods follows, with especial reference to the causative agents, modes of transmission, epidemiology, and methods of control. It is a concise and authentic text, and although it lacks an extensive bibliography, should prove an excellent addition to the scientist's library.

J. HAUB.

Insects and Disease of Man, by Carroll Fox. xii+349 pp. Philadelphia, P. Blakiston's Son & Co.

A Billion Years.

This addition to the Century of Progress Series tells the story of geology in terms that are readily understood by the non-technical reader, but which will be equally appreciated by the scientist. The geologic history of the earth is first developed, followed by the record of living things. The story of the glaciers is interestingly told. A thoughtful discussion of the future from the standpoint of practical geology concludes the book.—L. H. S.

The Story of a Billion Years, by W. O. Hotchkiss. x + 137 pp. Baltimore, The Williams and Wilkins Co., 1933.

Earth Lore.

Professor Shand has written an extremely useful book for those who are interested in geology, but who lack the technical vocabulary to enjoy the laborious reading of texts. Geology is here considered under the following heads: Seeing things to scale, the face of the earth, earth sculpture, the sea floor, the book of the rocks, the creation saga, the age of the earth, what lies beneath the crust?, deeper and deeper, chimneys in the crust, the problem of mountains, rifts and ramps, how is the crust held up?, drifting continents.

Both the author and the publisher are to be congratulated on this book. It is very readable and well executed.—W. BERRY.

Earth Lore. Geology without Jargon, by S. T. Shand. 134 pp. London, Thomas Murby and Co., 1933.

Geological Vocabulary.

This little book should fill the long felt need of a vocabulary of French to English for the geologist. It is not burdened with the more common words but abounds with those words that are so hard to find in the common literary dictionaries. It is expected that it will find considerable use, especially among the student, and the more experienced persons of geology.—W. BERRY.

A French-English Vocabulary in Geology and Physical Geography, by G. M. Davies. 140 pp. London, Thomas Murby and Co., 1932.

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ANNUAL REPORT

OF THE

OHIO ACADEMY OF SCIENCE

Forty-third Meeting

1933

Organized 1891 Incorporated 1892

Affiliated with the American Association for the Advancement of Science

PUBLICATION COMMITTEE

F. O. GROVER ERNEST CARMAN S. W. WILLIAMS

Date of Publication, August 10, 1933

TABLE OF CONTENTS.

OFFICERS AND COMMITTEES FOR 1933-34.

President

E. Lucy Braun

Vice-Presidents

Zoology: Neale F. Howard
Botany: Orville T. Wilson
Geology: Wm. A. P. Graham
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Herbert Osborn, *Chairman*, term expires....1935
Alpheus W. Smith, term expires....1936

Publications Committee

F. O. Grover, *Chairman*, term expires....1934
J. Ernest Carman, term expires....1934
S. W. Williams, term expires....1934

Library Committee

Mrs. Ethel M. Miller, *Chairman*,
In charge of Academy Exchanges and Publications
L. B. Walton, term expires....1934
F. O. Grover, term expires....1935
Frederick C. Blake, term expires....1936

Committee on State Parks and Conservation

Herbert Osborn, *Chairman*, term expires....1934
Edward S. Thomas, term expires....1934
W. E. Stout, term expires....1934
J. Ernest Carman, term expires....1935
E. L. Wickliff, term expires....1935
Roscoe W. Franks, term expires....1935
H. C. Sampson, term expires....1936
Edmund Secrest, term expires....1936
Emery R. Hayhurst, term expires....1936

Academy Representatives on the Joint Administrative Board, Ohio Journal of Science

C. G. Shatzer, term expires....1934
Edward L. Rice, term expires....1935

Academy Representatives on the Save Outdoor Ohio Council

Herbert Osborn, term expires....1934
E. N. Transeau, term expires....1934

Nominating Committee for 1934

Walter C. Kraatz
Bernard S. Meyer
Karl Ver Steeg
Fred A. Hitchcock
Louis D. Hartson
A. A. Atkinson
George D. Hubbard
William Lloyd Evans

REPORT OF THE FORTY-THIRD ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE.

WILLIAM H. ALEXANDER,
Secretary.

INTRODUCTORY.

The Forty-third Annual Meeting of THE OHIO ACADEMY OF SCIENCE was held on April 13, 14 and 15, 1933, on the charming campus of Ohio's oldest university, namely, OHIO UNIVERSITY, at Athens. This was the first meeting of the Academy in these historic walls and from the large attendance (356 in addition to those who forgot to register!) the selection was obviously a happy one and from the expressions of those present it is safe to say it will not be the fault of the Academy if another annual meeting is not held at this historic center within the next few years. The local executive committee, under the able and enthusiastic leadership of Dr. James P. Porter, did everything possible, it seemed, to amply provide for the needs of all. Two field trips to local points of interest were arranged; one to the Hocking County Park area, of interest to the members of the Sections of Geology and Geography, and the other to the Carbondale Coal Company's coniferous trees reforestation project, of special interest to entomologists and botanists. Ample provision was also made for the entertainment of the lady visitors.

Under the inspiration and able leadership of Dr. William Lloyd Evans, of Ohio State University, the efforts of the new SECTION OF CHEMISTRY to put on an attractive program were notably successful and the response of the chemists of the State enthusiastic, there being an attendance of more than one hundred at the first meeting of the section.

In addition to the large number of State institutions represented on the various sectional programs it is noted with pleasure distinguished representatives from the following institutions outside of the State were present and took part on the program: *University of Virginia*, *University of Chicago*, *University of Buffalo*, *University of New Hampshire*, and *Harvard University*.

The Annual Dinner on Friday evening (April 14) was, as usual, a most delightful affair, the only matter of serious regret being the demand for reservations exceeded the capacity (227) of the hotel banquet hall and so quite a number of late-comers had to be disappointed. Dr. James P. Porter served most acceptably as toastmaster on this happy occasion and the following program prepared by the local committee was put on immediately after the dinner:

Words of Greeting..........PRESIDENT E. B. BRYAN, Ohio University
"Onaway, Awake Beloved," (from Hiawatha).........*Coleridge-Taylor*
PHILIP PETERSON, Tenor
PRESIDENTIAL ADDRESS—"The Innocence and Guilt of Science,"
R. A. BUDINGTON, Professor of Zoology, Oberlin College
"Surely the Time for Making Songs Has Come".............*Rogers*
"My Lover Comes A-riding"............................*De Leath*
MISS HELEN HEDDEN
"Weather and Other Predictions,"
W. H. ALEXANDER, Secretary of the Academy;
U. S. Weather Bureau, Columbus, Ohio
SOCIAL HOUR

MINUTES OF THE BUSINESS MEETINGS.

(Stenographically Reported.)

First Session: April 14, 1933.

The first business session was called to order by President Budington at 9:08 A. M., in Memorial Auditorium, with a quorum present.

PRESIDENT: The first item of business is the announcement of committees. This is rather difficult because we are not sure just who is here. Dr. J. Paul Visscher, Chairman of the Committee on Membership, will report tomorrow morning. On this committee with Dr. Visscher are Professors Van Cleef and Hibbard. On the Committee on Resolutions are Professors F. C. Blake, E. L. Rice and H. C. Sampson. It seemed at first that the Committee on Necrology would have no special report, but now we learn of two deaths during the past year—Dr. E. B. Williamson and Dr. E. N. Clarkson. I am appointing on that committee Dr. R. C. Osburn, of Ohio State University, and Professor Otis, of Western Reserve.

The Secretary's report was then called for, read, formally approved and ordered filed.

The Treasurer's report was next called for. The Treasurer, A. E. Waller, prefaced the reading of his report by the statement that all bills had been taken care of up to this year and suggested further that the financial affairs of the Academy could probably be more effectively handled if the fiscal year were made to harmonize with that of the *Journal;* that is, be made the calendar year. The Treasurer's report, together with a review or audit of the report by an accountant, was then read.

Discussion.

PROF. F. C. WAITE: The purpose of our Auditing Committee is to check the Treasurer's accounts that someone besides the Treasurer may know just what the situation is and that errors may be checked. It is not a question of honesty or dishonesty. What has been done is that they have selected two men. But those men are not auditors, and the result is not an accountant's audit. It seems best to me that the matter should go on a plan of having a competent accountant do it.

Furthermore, the Journal, with whom we have business, and the American Association for the Advancement of Science, with whom we have business, both use the calendar year for their fiscal year, while we do not. It would seem to be desirable that our fiscal year should correspond with theirs. I would offer the following motion to change the by-laws. It is an amendment to the by-laws to replace *Section 3, Chapter V, on Audit*, as follows:

"The fiscal year of the Academy shall be coincident with the calendar year. It shall be the duty of the Executive Committee to secure an audit of all financial accounts by a competent accountant, who shall report to the Executive Committee before the annual meeting."

This report will save some time at the annual meeting. I move its adoption.

PROF. WALLER: I second the motion.

PRESIDENT: We really have two things in front of us now. This is really an item of new business for which we have a specific place on our program. You have heard the motion and its second. Perhaps, in order that we may finish one part of business before we begin on another, we should finish the Treasurer's report.

PROF. F. C. WAITE: Mr. Chairman, I brought this motion forward that it might go immediately into effect—that the report might be referred immediately to the Executive Committee instead of the Audit Committee.

PRESIDENT: Are there comments on this motion to amend?

PROF. STICKNEY: Are we competent to amend the by-laws?

SECRETARY: We are.

PRESIDENT: Are there other remarks to make along this line?

Motion carried.

PROF. F. C. WAITE: I now wish to offer a resolution to bring this amendment into effect. There are two parts to the resolution as follows: First, that for the year 1933, the fiscal year will be from April 1 to December 31; second, that this By-law immediately takes precedence over any present By-law with which it conflicts.

PROF. WALLER: I second the motion.

PRESIDENT: The motion before us is that the period from April 1 to December 31 shall be carried as a special item.

Motion was approved.

PRESIDENT: This disposes of the election by the Academy of an Auditing Committee, such election being now unnecessary.

PROF. E. L. MOSELEY: Should there be a motion for the acceptance of the present report?

PRESIDENT: This brings the amendment into effect immediately, instead of waiting for a year. The next item is Item b, Section 4 of our program.

SECRETARY: We have been following the practice of making the Vice-Presidents of the current year the Nominating Committee for the next year. If the Academy wishes to continue this practice the only motion necessary is one to instruct the Secretary to cast a written ballot for the current Vice-Presidents.

PROF. F. C. WAITE: I move to instruct the Secretary to cast a written ballot for the Vice-Presidents, as listed on the cover of the term program, to be the members of the Nominating Committee at the next annual meeting.

A second to the motion followed; also request for comments by the President. Motion was approved.

SECRETARY: I am pleased to cast a written ballot for the following persons to serve as a Nominating Committee for 1934, viz.:

WALTER C. KRAATZ	*Zoology*
BERNARD S. MEYER	*Botany*
KARL VER STEEG	*Geology*
FRED A. HITCHCOCK	*Medical Sciences*
LOUIS D. HARTSON	*Psychology*
A. A. ATKINSON	*Physics and Astronomy*
GEORGE D. HUBBARD	*Geography*
WILLIAM LLOYD EVANS	*Chemistry*

PRESIDENT: The next item is new business. Is there any new business which anyone has in mind?

PROF. LINDSEY: Because of the impossibility of each of us caring adequately for our valuable collections, it occurred to me, without having had an opportunity to discuss the matter with other interested men, that we might very well consider for the benefit of science in the State the centralization or consolidation of collections to the extent that it may be feasible. Dr. Osborn, who is here, knows more about this than I. I would, however, move the appointment of a committee of three to consider this question of consolidation under state support of the important collections of the State. This should be an economic measure, and it should make it possible for us to maintain centralized collections of our valuable things.

PRESIDENT: Are there comments to make in connection with this move? Professor Osborn, does this appeal to you?

PROF. OSBORN: I think I could second the motion. I don't know, of course, just how it would work out, but it seems a good arrangement, and I second the motion.

PRESIDENT: I wonder whether, since our time is short and our membership here in this meeting is small, we may not take Professor Lindsey's suggestion under consideration and talk it over among ourselves during the day, and then bring the thing up for final action tomorrow when there will be more of us here and when we can handle it a little more intelligently. We may bring this up under unfinished business tomorrow morning.

Is there other new business?

DR. PORTER: The suggestion has been made that after the adjournment of the business session we meet on the steps of the auditorium and have our pictures taken.

PRESIDENT: The group is very small.

DR. PORTER: Quality counts rather than quantity.

PRESIDENT: Does anyone here know whether Prof. Kendeigh has arrived? If there is only one address to be given in our next session, we should have time for the picture.

The President then declared a short recess and members assembled on the front steps of the auditorium where a photographer was in waiting. After the photograph had been made, the members reassembled in the auditorium and the business session was resumed.

The report of the Executive Committee was called for by the President and was read by the Secretary.

PRESIDENT: You have heard the Secretary's account of such business as the Executive Committee has carried out this year. Are there questions or comments? If not, what is your pleasure with reference to this report?

Report formally accepted and ordered filed.

PRESIDENT: The hour when our address in general session should begin is very near at hand. As it happens, we are much disappointed in not having Mr. Bennett with us for his part in this session. A telegram yesterday informed us that he was so engaged with affairs in Washington that he could not come up here. The consequence is that we do have a little more time than we might have otherwise had, but it will still be full. What shall we do with reference to the remaining reports? Can we postpone them until tomorrow?

SECRETARY: I think so, Mr. President.

Meeting adjourned.

Immediately following the adjournment of the First Business Session on Friday, April 14th, the first and only General Scientific Session of the Academy was called to order by the President in Memorial Auditorium at 10:10 A. M. As announced by the President, word had been received that Mr. H. H. Bennett, of Washington, D. C., had been unavoidably detained and could not be present for his address, much to the disappointment of the Academy.*

*However, Mr. Bennett supplied a copy of the address he would have given had he been present and same is published elsewhere in these Proceedings.
—W. H. A.

Accordingly the President introduced Dr. F. C. Waite, of Western Reserve University, who gave a most interesting illustrated lecture on "The Early History of the Microscope."

This was followed by a most interesting lecture, also illustrated, on "Toleration of Low and High Air Temperatures by Birds," by Dr. S. Charles Kendeigh,* of the Baldwin Bird Research Laboratory and Western Reserve University, at Cleveland.

Second Session: April 15, 1933.

Meeting was called to order at 8:35 A. M.

PRESIDENT: The first item of business is item b, Section 6, of our program; report of the Publications Committee by Prof. E. L. Moseley.

Prof. Moseley's report was read and followed by the following suggestion in form of motion by Prof. Moseley: "That the Publications Committee be authorized to get an estimate of the cost of the publishing of the new edition of Lynds Jones' *Birds of Ohio* and the decision as to publication be referred to the Executive Committee in conjunction with the Publications Committee."

Motion was seconded and carried.

Report of Trustees of the Research Fund was made by Prof. Herbert Osborn.

PRESIDENT: According to the step which was taken yesterday morning, this financial statement will be passed upon by a competent accountant and the accountant's report passed to the incoming Executive Committee, who will then handle it and consider the account audited properly. This really means, of course, that we are putting into operation the plan of having all Academy accounts audited by an accountant rather than by two or three of our semi-ignorant members. We are going to put all our funds into such form and handle them in that way. It seems as if this is the only business-like way of taking care of our finances. Since this motion was passed yesterday morning, I assume there is nothing further for us in the Academy to do. Is there a report as to grants which were made from the Research Fund for the year, Mr. Osborn?

PROFESSOR OSBORN: No expenditures were made. Other

members think it advisable to let the fund accumulate rather than make grants this year.

PRESIDENT: Whatever may seem best to be done will be decided by the committee on this Fund when the communication goes to them. Does someone move this report be accepted?

Motion made, seconded, and report accepted.

PRESIDENT: The next report is from the Library Committee by Mrs. Ethel M. Miller.

Mrs. Miller read her report and offered a suggestion that members, each of whom had been sent two publications from the Ohio Biological Survey, return the copies if they did not care for them.

PRESIDENT: You have heard the carefully prepared report of Mrs. Miller. Are there questions or remarks? Mrs. Miller has already submitted to the Executive Committee a full financial statement of the funds and expenditures which she has just reviewed. This will be submitted to a professional accountant and then formally accepted by the Executive Committee.

Motion made, seconded, and carried that report be accepted.

PRESIDENT: The next report is from Prof. Osborn again for the Committee on State Parks and Conservation.

Following this report, motion was made, seconded, and carried that it be accepted.

PRESIDENT: We now come to reports of the Special Committees. We will listen to a report on the Election of Fellows by the Secretary.

SECRETARY: After two years' trial, I have the rather settled conviction—and I think this feeling is very largely shared by the present committee—that the 60-day limit for filing the nominations to fellowship is somewhat too long and for that reason the committee decided at its meeting last evening to ask the Academy to amend the rule by making it 30 days instead of 60.

PRESIDENT: The suggestion accomplished this: That the preliminary notice which calls your attention to the nomination of Fellows should be sent out forty-five days before the annual meeting, giving each two weeks to send in nominations. The trouble now is that they practically never come in sixty days ahead, and the probability is that any special requirement will be waived, because otherwise there would be no elections

to be made, but it seems if it is reduced to thirty days, we might be able to stick to it. That would be wholly reasonable. Perhaps sixty days is reasonable too, but it doesn't seem to be working well.

PROF. DELONG: I do not deem the present system of electing members to the Fellowship to be fair and therefore suggest that a special Fellowship Committee be set for the purpose of canvassing the whole membership in an attempt to choose those members who may be eligible and ought to be chosen.

PROF. TASHIRO: Instead of the thirty-day limit for the filing of nominations as suggested by the Committee on the Election of Fellows, why not set a certain line of demarcation, as, for instance, March 10?

PRESIDENT: One difficulty with that would be, I think, that we have to regulate, to a certain degree, the date of our meeting according to the convenience of our host.

PROF. TASHIRO: That would make no difference; just make it one date, no matter when the meeting comes.

PRESIDENT: Under some circumstances, though, you would only have twenty days, and under others you would have forty, depending upon the relation of the date of the meeting and March 10, which you suggest.

DR. MOSELEY: Sometimes our meetings come within the month of March.

PROF. R. C. OSBURN: How far ahead of time is the first announcement prepared and distributed?

PRESIDENT: The suggestion last night was forty-five days ahead.

PROF. R. C. OSBURN: The date in the announcement would be definitely set so that we would know that nominations would have to be by a certain date.

DR. DELONG: I am willing to make a motion that a Fellowship Committee be appointed to nominate all the Fellows who are eligible.

DR. ENGLISH: It would be preferable if each section were instructed to set up for itself a Fellowship Committee, which Committee should have a certain degree of preference and be charged with an annual survey of the section to determine which of its members should become Fellows. I don't see how any person could hope to be familiar enough with two or three interests represented in the Academy, and with the personnel

of the Academy, to enable him to say, by merely seeing a name, whether that person should be a Fellow. I should like to ask Dr. DeLong to substitute this clause in his motion.

DR. DELONG: My idea is that there should be a centralized committee.

PRESIDENT: The Secretary reminds me that that is in effect the situation now.

DR. F. C. WAITE: The present plan of having the Vice-Presidents, ex-officio, act as the Nominating Committee rests on the presumption that they are acquainted with the members of their own sections; that they make the best Committee there is; that they are acting with their own sections and know more about the members in their own sections than any other one person. If you set up another committee, it simply makes *another committee*, and the difficulty of getting members on that committee who will work together is great.

Another thing; this thing of going out and trying to canvass someone who might possibly be made a Fellow is not the right attitude. Fellowship is supposed to be an attribute to outstanding work. This question of trying to make everybody a Fellow decreases the worth of the Fellowship. Often there have been proposals that certain members be solicited for Fellowship who are not eligible. It is embarrassing to have to turn them down after they have been recommended like that. We all know that every additional committee is simply a problem in finding men to serve on it.

PROF. E. L. RICE: I would like to raise the question whether the Academy is agreed whether it is worth while to have a Fellowship at all. As I am a fellow myself, I don't hesitate to make the suggestion that it be discontinued.

DR. DELONG: There are those in our group who are autocrats and desire class distinction. I am not one of these. I do not agree with Dr. Waite's view.

PROF. SMITH: We haven't made a recommendation on Dr. Alexander's suggestion. I move its approval.

Motion seconded and carried.

A MEMBER:* Is it true that the Committee does not have power to nominate Fellows unless the nomination is placed with them? If we give that Committee power to make decisions themselves, it might relieve the situation.

*Name not caught by the stenographer.

THE SECRETARY: Mr. President, may I suggest in reply to the question just asked by the gentleman that the members of the Committee on the Election of Fellows *as individual members*, like any other members, have the right to submit nominations but it would be manifestly farcical for the Committee as a whole to make nominations and then sit in judgment on their fitness. You understand the Academy as a whole has nothing whatever to do with the election of fellows; that duty by constitutional provision is imposed upon this committee. Its action is final.

PRESIDENT: I think they have that privilege as individuals. If no one objects, the next item of business will be the report of the Committee on Memberships by Prof. Visscher.

After the report, a motion was made, seconded, and carried, that the applicants mentioned be elected to membership.

PRESIDENT: The next item is the report on Necrology by Professor Raymond Osburn.

Report read by Professor Osburn.

PRESIDENT: We regret to hear so many names included in this report. What shall we do with this report?

Motion made, seconded, and carried, that it be accepted and filed.

PRESIDENT: The next report comes from representatives on the Joint Administration Board of the Ohio Journal of Science.

In the absence of Dr. Meyer, Chairman of the Board, the report is read by Dr. Rice.

Motion made, seconded and carried that the report be accepted and placed on file.

DISCUSSION.

PROF. RICE: Does that acceptance carry those two recommendations included in that report? Also, does that make official the arrangements we made last year? We can find no record of any adoption of that report other than the printing was carried out. I assume that the acceptance of this report covers both those points.

PROF. ENGLISH: I would like to raise an issue at this point of the relationship of the Academy to the Journal. One dollar and fifty cents of our dues go to the Journal and 50 cents for the cost of the Proceedings. That means the Academy is run on about 50 cents a year aside from the Proceedings and Journal. The Journal is predominantly a Journal of Biological

Science. It probably should be continued as such. I am not raising the question, in any sense, critical of the editorial policy. At the same time, such a Journal inadequately serves the wide variety of interests represented in the Academy. It is true that members should have a general interest in science, and many are receiving other science publications, but, even so, $2.50 does amount to something. A few of our distinguished members have withdrawn because they did not feel they could meet the dues. Now, if the Academy should subsidize the Ohio Journal, I think we should do it on a flat rate; and I question whether we should automatically tax all the members of the Academy for a Journal which, for most of them is not read—or, I should say, many of them—or needed. I move as an amendment that hereafter the Journal be optional to members of the Academy and that dues be reduced to $1.00 a year for those who do not receive the Journal, such members to receive a copy of the annual transactions. That still leaves 50 cents for each member as a tax for subsidy of the Journal, a journal which he doesn't receive; but it is important that the Ohio Journal be continued, and such a subsidy as that might be tolerated.

PRESIDENT: Are there further comments to make?

PROF. RICE: Mr. President, I think it rather unfortunate that I should have brought up that technicality that we had no record of the action we discussed last year. What the effect of a cut like that proposed would have on the Journal, is hard to tell. It would at least curtail its size. It would throw the Journal in a state of chaos. As regards the use of the Journal by different sections of the Academy, the Editor was expressing only the other day his desire and ambition to make this Journal of interest to others. The fact that it has been almost purely biological is because no other papers have been submitted for printing.

PROF. SEYMOUR: It is undoubtedly true, as interested as I am in biological science, I frequently find a Journal which contains little of interest. On the other hand, I often find a Journal which is all interesting. Our exchange list is of major interest to every member. If the Journal should be discontinued, our whole exchange list would be wiped out.

PROF. SNYDER: As Editor, I would like to say that we now have many sections in addition to biology. Any article which

we have received other than biological articles, has been printed immediately. I should dislike to see the Journal curtailed. In fact, it is already curtailed. An Academy cut would justify the University in also making a cut.

I think the desirable thing would be to make the Journal available to every section if we can get people to see that articles come in to us. We should be only too glad to publish papers for other sections, as we have, to some extent, during the past year.

DR. F. C. BLAKE: I want to explain why there aren't any physics papers being published. I appreciate the idea of Dr. English. The American Institute of Physics is publishing eight or nine Journals, and that provides us a complete method of publication. Our laboratory work is of a national character, and there is no particular reason for our publishing our papers other than nationally. I have had a policy of turning my Journal back to Mrs. Miller. Others are doing the same thing. We cannot expect to be publishing in the Journal of Science much because of our national outlet, for the reason I have just stated; but, nevertheless, we are heartily in sympathy with the enlargement of the Journal, and I shall do what I can to see that we get a section editor that will deliver more physics papers.

DR. WAITE: I consider this debate out of order. The real question is concerning the report of Dr. Rice.

PRESIDENT: As a matter of fact, I think we voted on the report of Dr. Rice. It was accepted. It was after it was passed that this question came up. We now have before us, of course, the motion of Prof. English. It has been seconded and comments on his motion have been advanced.

I think Prof. Rice has pointed out the seriousness of taking a step of this kind until we really know more of what the consequences would be. I don't think we are familiar enough with the matter to see just what this would mean. It strikes me that it is a legitimate question, and we are not prepared at this session to vote very intelligently upon it. The management of the Journal should be consulted as to what such a move would mean. We are all interested in the Journal to some extent and would not want to handicap it too far.

PROF. BURT: I think it would be unfortunate, perhaps, to take ill-considered action on this at this time, although,

personally, I am somewhat in favor of the proposition. I should like to move this matter be referred to the Executive Committee to canvass the members before the next meeting as to their opinions on the subject, and to go over it with the Publications Committee; that the whole thing be referred to the next annual meeting.

DR. WAITE: I think the Publications Committee should consult with the Executive Committee on this.

DR. ENGLISH: I agree to Prof. Burt's suggestion and wish to assure Dr. Waite that my reason for bringing this matter up at this time is that the acceptance of Dr. Rice's report did not carry with it the continuance of the policy which has been adopted by the Academy from year to year, and I therefore deemed the time appropriate to bring up the matter; I certainly do not wish to have the matter taken as a snap judgment; I believe every member should be canvassed concerning it. I withdraw my motion with consent of the second.

PRESIDENT: I understand that the first motion which was made by Prof. English has been withdrawn, and in place of it we have before us the motion which was made by Prof. Burt with reference to referring this to the Executive Committee and the Joint Administrative Board of the Ohio Journal of Science for investigation, including a canvass of the membership and report at the next annual meeting.

Doctor Rice then raised the question as to just what Committee was referred to, and it was ascertained that the committee meant was the Committee representing the Academy on the Administrative Board of the Journal of Science.

Motion carried.

PRESIDENT: The next report is on the Save Outdoor Ohio Council, to be given by Prof. Herbert Osborn in the absence of Prof. Waller.

Report read, formally accepted and placed on file.

Following the reading of this report pamphlets concerning conservation of forests, land, wild life, etc., were distributed by Dr. F. H. Krecker.

PRESIDENT: The report of the Nominating Committee will be made by Dr. DeLong.

President called for further nominations in addition to those read by Dr. DeLong. Motion was made, seconded, and

carried, that the Secretary cast a unanimous ballot for the list mentioned in the report.

PRESIDENT: The next thing is unfinished business. One matter left over from yesterday was Dr. Lindsey's motion to establish a central collection.

Dr. Lindsey withdrew motion because of lack of time.

The President called for other business. Report was then read by Dr. Baird on publication of work for junior scientists. Further discussion of the matter was referred to the Executive Committee by unanimous agreement.

PRESIDENT: We are now ready for the report of the Committee on Resolutions by Prof. Blake.

Report was read by Dr. Blake and unanimously approved.

PRESIDENT: Does someone wish to make a motion that the question of the place and time for the next meeting be referred to the Executive Committee?

Motion made, seconded and carried.

SECRETARY: The question of electing an Academy representative on the Council of the American Association for the Advancement of Science and the Academy Conference, also a representative on the Save Outdoor Ohio Council, should also be referred to the Executive Committee.

Accordingly, the matter was referred by formal motion to the Executive Committee with power.

Meeting adjourned, *sine die*, at 10 A. M.

THE SCIENTIFIC SESSIONS.

GENERAL AND SECTIONAL.

The following is a complete list of the addresses and papers presented at the various general and sectional meetings of the Academy as reported to the Secretary:

1. THE PRESIDENTIAL ADDRESS: The Innocence and Guilt of Science, R. A. BUDINGTON
2. Architecture in Ohio .... F. J. ROOS
3. The Cost of Soil Erosion (by title) .... H. H. BENNETT
4. The Early History of the Microscope .... F. C. WAITE
5. Toleration of Low and High Temperatures by Birds .. S. CHARLES KENDEIGH
6. Germ-cells and Early Development of Arbacia as Affected by Aspirin, R. A. BUDINGTON
7. Further Studies of the Nature of the Golgi Apparatus Leading to a Discontinuance of the Use of the Term .... HOPE HIBBARD

8. Growth and Yolk Formation in the Parthenogenetic Eggs of *Daphnia magna*....................HYMAN LUMER
9. Antennal Regeneration of *Daphnia magna*....................B. G. ANDERSON
10. Migrations and Aggregations of Paramecia in Response to pH, Carbon dioxide, and Oxygen....................EDGAR P. JONES
11. Further Studies on the Behavior of Barnacle Larvae......J. PAUL VISSCHER
12. Organisms Found in 30 c. c. of Material Collected from a Quarry Depression on Kelley's Island, August, 1932........STEPHEN R. WILLIAMS
13. Are Natural Mutations Random Occurrences?..........WARREN P. SPENCER
14. Some Observations on the Stability of Mutations........ROBERT A. HEFNER
15. Studies on the Common Checkered Skipper....................A. W. LINDSEY
16. Ecological Studies of *Argia moesta* Hagen (Odonata: Coenagrionidae) by Means of Marking....................DONALD J. BORROR
17. A Study of the Gross Anatomy of the Brain of the Garpike, *Lepisosteus osseus*..................TOMAS VAN SICKLE (Read by WALTER C. KRAATZ)
18. Parasites of the Spotted Bass, *Micropterus pseudaplites* Hubbs., RALPH V. BANGHAM
19. The Relative Infestation of Birds by Mallophaga.........ROBERT M. GEIST
20. Avian Tuberculosis in the Eastern Song Sparrow..........LOUIS B. KALTER
21. Fall and Winter Behavior of Song Sparrows.......MRS. MARGARET M. NICE
22. The Red-bellied Water Snake, *Natrix sipedon erythrogaster* (Forster) in Ohio....................ROGER CONANT
23. An Experiment in Teaching Freshman Zoology without Required Dissection....................ARAVILLA M. TAYLOR
24. Some Field Notes and Junior Scientists....................ROBERT L. BAIRD
25. Introductory Remarks: Investigations in the Hydrobiology of Ohio, RAYMOND C. OSBURN
26. Hydrobiological Survey of the Western End of Lake Erie. An Account of the Work and Methods of the Survey Conducted by the Ohio Division of Conservation....................E. L. WICKLIFF
27. Summary of Limnological Investigations of Western Lake Erie in 1928, WILBUR M. TIDD
28. Summary of Limnological Investigations of Western Lake Erie in 1929 and 1930................STILLMAN WRIGHT (read by E. L. WICKLIFF)
29. The Crustacea Used as Food by the Young Fishes in Lake Erie, LELA EWERS
30. Summary of Limnological Investigations of Buckeye Lake in 1930, E. L. WICKLIFF
31. The Invertebrate Shore Fauna of Western Lake Erie.......F. H. KRECKER
32. Preliminary Limnological Investigations of the Major Impounded Waters of Ohio....................LEE S. ROACH
33. The Ecology of an Intermittent Stream................JAMES W. BRANSON
34. The General Effects of Pollution on Ohio Fish Life....MILTON B. TRAUTMAN
35. The Relation of Clumping to the Rate of Oxygen Consumption and Toxic Action of Salts in *Sparganophilus eiseni*, EMMETT ROWLES AND OSCAR TURNER
36. The Effect of Sedimentation on the Rate of Oxygen Consumption in Various Fishes....................P. S. SHURRAGER AND EMMETT ROWLES
37. A Study of the Insect Fauna of a Coniferous Reforestation Area in Southeastern Ohio....................GEORGE R. EASTERLING
38. Milo G. Williams, Botanist (1804–1880).............MARGARET B. CHURCH
39. Introducing the Ohio State University Botanic Garden.......A. E. WALLER
40. Light in Relation to the Germination of Certain Seeds.....JESSE D. DILLER
41. Hydrogen Ion Relations of Some Ohio Mosses........GILFORD J. IKENBERRY
42. "Bound Water" in Relation to the Cold Resistance of Pitch Pine, BERNARD S. MEYER
43. A Unique Raised Bog at Urbana, Ohio....................ROBERT B. GORDON
44. Supernumerary Parts and Adnation in the Flower Parts of *Lycopersicum esculentum*....................LEON HAVIS
45. Duplicate Evolution of Peculiar Perianth Structures in the Sedges and Composites....................JOHN H. SCHAFFNER
46. Ericales of Western North America....................W. H. CAMP
47. The Algae of Oklahoma....................CLARENCE E. TAFT

48. Variations in Unicellular Algae........................Elbert H. Ahlstrom
49. The Vascular Flora of Ashtabula County, Ohio.........Lawrence E. Hicks
50. The Distribution of the Tulip Poplar in the Central States, Leonard F. Kellogg
51. Flora in Roof of Upper Freeport Coal at Callahan's Mine, Teegarden, Ohio...Willard Berry
52. Further Study of the Drainage History in the Old Steubenville River Basin...G. F. Lamb
53. Glacial Boundaries in Northeast-central Ohio............George W. White
54. Re-excavated Valleys in Southern Ohio as a Proof of the Lowering of a Land Surface by Inter-stream Degradation.............John L. Rich
55. New Species from the Silica Shale of Lucas County, Ohio..Grace A. Stewart
56. An Extension of the Rock Unit Called Silica Shale.......J. Ernest Carman
57. Pre-Illinoian Sediments and Deep Soils on Bed-rock Near Cincinnati, Ohio..Walter H. Bucher
58. The Relation of Soils to Geology in Adams County, Ohio.
    (a) In General........................G. W. Conrey and A. E. Taylor
    (b) In the Disturbed Area of Northern Adams County...John T. Miller
59. Announcement of Plans for the Annual Spring Field Trip...Karl Ver Steeg
60. The Role of Forest Cover in the Control of Erosion and Run-off, Edmund Secrest
61. Problems in Lower Mississippian Correlations..........Paris B. Stockdale
62. A Plan for Increasing Interest in Geology in Ohio.........Richard C. Lord
63. Preliminary Report on the Cambrian Limestone.......Robert H. Mitchell
64. Parker Straths Near Cincinnati........................Louis Desjardins
65. Buried Channels at Cincinnati as Revealed by Borings......Otto Gutenson
66. Additional Evidence on the Physiographic Development of Straths and Post-strath Warping..............................M. Meredith Sheets
67. The Micro-fauna of the Vanport Limestone in the Youngstown Region, Edgar L. Stephenson
68. A New Inter-glacial Deposit Near Oxford, Ohio..............J. J. Wolford
69. The Black Hand Formation in Knox County, Ohio........Richard C. Lord
70. Sedimentation in Upper Cretaceous Sea of Utah.......Edmund M. Spieker
71. Paleozoic Formations in Virginia...........Arthur Bevan, State Geologist
72. The Upper Roanoke and Greenbriar Basins..............Frank J. Wright
73. The Physiography of Jehol, North China..............George B. Barbour
74. Devonian Shales of Eastern Kentucky.....Appalachian Geological Society
75. The Work of the Harrisburg Erosion Cycle............Nevin M. Fenneman
76. Bone-beds and Associated Crinoidal Sands of the Delaware Linestone, Lewis Westgate and Richard P. Fischer
77. The Cow-Run Sandstone in East-Central Ohio.................C. F. Moses
78. Insoluble Residues of Niagaran of Southwestern Ohio.Richard A. Edwards
79. Late Crystallization in Resorbed Plagioclase Phenocrysts.....Harold Fisk
80. Recurrent Coral Faunas of the Ordovician...................W. G. Meyer
81. Truncation versus Peneplanation............................John L. Rich
82. Boulder Fields of the Northern Appalachians..............Karl Ver Steeg
83. Problems of Limestone Cave Origin. (Read by title)....A. C. Swinnerton

Symposium on Endocrinology.

84. The Effect of the Anterior Pituitary on the Composition of Growth, Dr. M. O. Lee, Harvard University
85. The Thyroid and the Iodine of the Blood..........Dr. George M. Curtis
86. The Functions of the Adrenal Cortex, Dr. Frank A. Hartman, The University of Buffalo
87. The Male Sex Hormone.............Dr. F. C. Koch, University of Chicago

Symposium on Blood Discrasias.

88. Hereditary Factors in Diseases of the Blood.............Dr. L. H. Snyder
89. Nutritional Anemia....................................Dr. Ernest Scott
90. The Clinical Anemias...............................Dr. George Nelson
91. The Problem of White Blood Cell Equilibrium.............Dr. C. A. Doan
92. A New Test to Measure Appreciation of Poetry.........Prof. Melvin Rigg
93. Profiles of Unsatisfactory College Students...........Prof. C. O. Mathews
94. Item Analysis: The Basis for Constructing a Test for Forecasting Supervisory Ability..............................Dr. R. S. Uhrbrock

95. An Experiment in Selecting Test Items .... MISS DOROTHY C. ADKINS
96. Rivalry in Young Children .... CLARENCE J. LEUBA
97. A Photographic Study of Emotional Facial Expressions in the Second Year of Infancy .... HORACE CHAMPNEY
98. The Influence of Organization by the Learner on Permanence of Learning .... H. B. ENGLISH
99. The Influence of Surface and Tint of Paper on the Speed of Reading, FRANK H. STANTON
100. Effect of Head Tilt upon Visual Localization in Horizontal Plane, WINFORD L. SHARP
101. Temporal Factors in the Formation of Conditioned Eyelid Reactions in Human Subjects .... MR. ARTHUR BERNSTEIN
102. The Influence of Rate and Direction of Change on Comparative Pitch Judgments .... MR. WILLIAM SCHWARZBEK
103. Some Observations on Learning and Relearning in the Hypnotic Trance vs. the Waking State .... MR. M. K. WALSH
104. A Preliminary Report on the Fels Study of Fetal Movement, DR. ROBERT F. WALLACE
105. The Nature of Emotion and its Relation to Anti-Social Behavior, MR. FRED BROWN
106. Informal Reports Concerning Laboratory Work in Progress.
107. *The Theory of Radio Field Intensity Measurements* .... D. B. GREEN
108. The Design and Application of a Radio Field Intensity Meter, RUSSELL V. KELCH
109. Neutrons in the Structure of the Nucleus .... A. LANDE
110. History of the Neutron .... HOMER C. KNAUSS
111. Fluoresence of Chlorophyll (b) .... V. M. ALBERS AND H. V. KNORR
112. Demonstration in Mechanical Resonance .... T. D. PHILIPS
113. Crystal Structure of Lithium Sulfate .... JOHN G. ALBRIGHT
114. A Visual Modification of the Sonometer Experiment .... C. E. HOWE
115. A Thermo-electrically Driven Pendulum .... JOHN G. ALBRIGHT
116. Rapid Computation of Energy Distribution in Black Body Radiation, CEDRIC E. HESTHAL
117. A Symposium on Cultural Physics Courses.
    How Can We Make Our Physics Courses Have More Meaning for the Lay Student? .... R. J. HAVIGHURST
    A. Cultural Physics Course at Ohio State University .... H. P. KNAUSS
    A Modification of the Traditional Approach to General Physics, L. W. TAYLOR
    The Physical Course at Antioch .... G. E. OWEN
118. Calculation of X-Ray Scattering Coefficients as a Function of the Wave Length .... L. M. HEIL
119. Additional X-Ray Absorption Coefficients Using the F-P-54 Pilotron, JOHN E. EDWARDS
120. Some Common Errors in Physics Textbooks .... T. D. PHILIPS
121. The Evolution of the Thermometer. (Demonstration) .... EARL H. BROWN
122. The Apparent Effects of Lake Erie on the Weather of Northern Ohio, ROBERT O. BRINK
123. The Democartography of Ohio .... GUY-HAROLD SMITH
124. Influence of Cincinnati on Agriculture .... W. R. MCCONNELL
125. Yellow River .... GEORGE B. BARBOUR
126. The Geography of Italy's Recent Expansion .... RODERICK PEATTIE
127. Negro Residential Occupance in the Chattanooga, Tennessee, District, NATHANIEL C. BURHANS
128. Soil Type as a Factor in Crop Distribution in Athens County, Ohio, G. W. CONREY AND A. H. PASCHALL
129. The Use of Air Photographs in Geographical Studies in Ohio .. G. W. CONREY
130. A Map Study of Ohio .... JOHN H. GARLAND
131. Dayton: Geography of a Confluent Site .... ALFRED J. WRIGHT
132. Urban Location *versus* Accessibility .... EUGENE VAN CLEEF
133. Reconnaissance Method in Urban Geography .... MARGARET E. STEVENS
134. Wellington, Ohio: A Rural Village .... WALTER W. RISTOW

135. The Application of the Dead Stop End Point to Titrations with Ceric Sulfate.............................D. R. CLIPPINGER AND J. F. CORWIN
136. A Student Problem in Electro-Analysis, GROVER L. ORR AND KENNETH L. ROBERTS
137. Quantitative Spectroscopic Estimation of the Metals, W. R. BRODE AND J. G. STEED
138. The Use of the Polarograph in Chemical Analysis.......RICHARD BRADFIELD
139. The Modern Barium Industry..........................JAMES R. WITHROW
140. The Present Status of Municipal Water Softening.............C. P. HOOVER
141. The Chemistry Courses in the Small College..................K. G. BUSCH
142. An Electrical Conductivity Apparatus for a Laboratory of General Chemistry............................J. E. DAY AND JAMES K. FARRELL
143. Interfacial Tension and the Phenomenon of Wetting......HARRY N. HOLMES
144. The Solubility of Silver Oxide in Alkali and in Alkaline Salt Solutions and the Amphoteric Character of Silver Hydroxide, A. B. GARRETT, F. CUTA AND HERRICK L. JOHNSTON
145. Some Thermodynamic Properties of the Neutral OH Molecule Computed from its Spectra....DAVID H. DAWSON AND HERRICK L. JOHNSTON
146. The Reductivity of Hydrogen. III. Ferric Sulfate.........RAYMOND HOOD
147. Metal Salts of the Alcohols and Alcohol Analogues............OTIS DERMER
148. Studies on Protochlorophyll. Reduction of Pure Chlorophyll and of Pheophytin..PAUL ROTHEMUND
149. An Alkali Stable Complex Carbohydrate from Aerobactic Aerogenes, HAROLD M. WHITACRE AND HARVEY V. MOYER
150. New Syntheses in the Olefine Series......IMAN SCHURMAN AND C. E. BOORD

DEMONSTRATIONS AND EXHIBITS.

1. Limnological Equipment. (Various pieces of equipment used in quantitative plankton work, and other types of limnological investigations.) Exhibited by the Ohio Division of Conservation and Ohio University.
2. Modified Qualitative Plankton Tow Net with Bucket. Exhibited by Lee S. Roach, Uhrichsville High School.
3. Small Birge Closing Quantitative Plankton Tow Net. Exhibited by W. C. Kraatz, University of Akron.
4. Home-made Devises for Use in Mounting Sections. Exhibited by Emory S. James, Ohio Wesleyan University (introduced by Edward L. Rice).
5. A Method for Demonstrating Fruit Flies and Other Small Insects. Exhibited by Warren P. Spencer, College of Wooster.
6. An Exhibit of Certain Groups of Insects of Southeastern Ohio, including Collections of Orthoptera—Butterflies, Velvet Ants, Tiger Beetles, Lady Beetles, and a few rather uncommon Species of Various Other Groups. From the Biology Department, Ohio University, arranged under the direction of Mr. William C. Stehr, Assistant Professor of Biology, Ohio University.
7. The Evolution of the Thermometer, by Earl H. Brown, Antioch College.

REPORTS.

Report of the Secretary.

ATHENS, OHIO, April 14, 1933.

To the Ohio Academy of Science:

Your Secretary is pleased to submit herewith his tenth annual report, very briefly stated. These ten years have brought with them many inevitable changes and have left their marks in many places and on all our faces! Quite a number of those who gathered with us at the little meeting in Oberlin just ten years ago are no longer seen or heard among us! The Secretary recalls as if it were only yesterday the shock of surprise when his beloved and greatly admired friend, the late Dr. Thomas Corwin Mendenhall, as chairman of the Nominating Committee read out, "For Secretary, William H. Alexander, of Columbus!" My greatest ambition and inspiration have been during all these ten years to be worthy of the confidence placed in me by the Academy, with the knowledge and consent of that courtly gentleman and scholar! If he were in our midst this morning would he, could he, say, "Well done, good and faithful servant!" The continued confidence of old friends and the making of new ones constitute the chief reward for the onerous duties of the office.

Our membership for reasons known to all has suffered losses during the year now closing and the recruits have not fully replaced these. Most fatalities occurred at the gate called "Dues," so carefully guarded by a skillful, sharp-shooting Treasurer! As the casualties are not always promptly reported to the Secretary, the two lists are not in perfect agreement at all times. We will therefore await the report of the Treasurer as to the present membership list.

Probably the outstanding events of the year were, first, the sponsoring by the Executive Committee of the Academy of a series of radio talks on popular subjects by members of the Academy extending from January to April, inclusive, more fully noted in the report of the Executive Committee. (See Appendix B.) This effort, of course, imposed considerable work on the Secretary, but in view of the high aims and the ready, hearty response of members, the work was a pleasure. The second event of note was the organization of the *Section of Chemistry*. (See Appendix A.) In this the Secretary played a minor part to be sure, but to have even a very small part in a real event is some satisfaction.

Otherwise, the work of the Secretary has been almost wholly routine and there is neither time nor need for a recounting of monotonous details at this time.

We desire to commend most cordially the earnest and obviously successful efforts of the vice-presidents in searching out and securing such an array of talent for the sectional meetings, as shown on the printed program of this meeting. We believe the Academy was never more firmly established on the high road of useful and helpful service nor looked forward on a brighter future. We bespeak for it the loyal, enthusiastic work and support of every member.

Again, good friends, for your kindly, helpful thoughts, words and deeds, most hearty thanks. For our shortcomings we ask your indulgence, and for the future an encouraging smile!

Respectfully submitted,

W. H. ALEXANDER,
Secretary.

Report of the Treasurer for the Year 1932–1933.

ATHENS, OHIO, April 14, 1933.

To the Ohio Academy of Science:

Despite evident hardship on the part of some individual members of the Academy the payment of dues has been excellent under the present conditions. It is evident that the members of the Academy show a loyalty to an organization which they desire to support. There have been a number of resignations which the Treasurer has had reluctantly to accept. It is to be hoped that they will be counterbalanced by an equal number of new members who will remain with the Academy.

Economies have been effected by not publishing a separate Proceedings and by reducing the amount of printed matter in the Proceedings. The reduction will not become effective until next year, as the present report includes the cost of the Proceedings issued last July.

The investment of the Academy is in the form of Liberty Bonds, of which we have $1,750.00.

With the economies in the Proceedings, namely, the elimination of the membership list, the elimination of abstracts of papers presented at the meetings and the reduction to the minimum of the printed matter concerning the position of the Academy, it probably will not be necessary to withdraw any funds from the permanent investment at the present time. For this the members of the Academy are to be gratefully congratulated.

RECEIPTS.

Cash balance on hand April 25, 1932	$ 222.19
Receipts from Sale of Publications	46.85
Received from A. A. A. S	144.50
Dues from Members; Back Dues Collected	913.00
Transferred from Trust Account (during Bank Holiday)	37.65
Interest from Bonds	74.41
Deposited by error of Bank to wrong account	7.00
Total Receipts	$1,445.60

Total Receipts	$1,445.60
Total Disbursements	1,007.45
Cash balance on hand April 1, 1933	$ 438.15

DISBURSEMENTS.

W. H. Alexander, Secretary's Honorarium	$ 100.00
Spahr & Glenn Co., for Programs, 42nd Annual Meeting; Statements, Letterheads, 100 Return Envelopes, Preliminary Announcements, and Radio Program	99.67
Roof Stenographic Service, for the Secretary	24.67

C. J. Shatzer, Report of Junior Scientific Endeavor	23.15
E. M. Spiker, Expenses for Geol. Section, 42nd Annual Meeting	5.96
D. M. DeLong, Expenses for Zool. Section, 42nd Annual Meeting	1.40
One-cent Postage Stamps, Rose McCabe	10.29
H. B. English, Expenses for Vice-President for 42nd Annual Meeting	4.00
F. G. Tucker, Expenses for Vice-President for 42nd Annual Meeting	7.32
A. T. Evans, Expenses for Vice-President for 42nd Annual Meeting	9.00
Shiro Tashiro, Expenses for Vice-President for 42nd Annual Meeting	9.40
Herbert Osborn, check credited to account by error of Bank	7.00
R. A. Budington, Expenses for Executive Committee, 1932 Meeting	4.08
M. E. Stickney, Expenses for Executive Committee for 1932 Meeting	1.80
J. C. Goodman, "Save Out-Door Ohio" membership Dues	12.00
B. S. Meyer, Business Manager, Ohio Journal of Science, for 167 members in the Academy for 1932, at $1.50 each	250.50
R. A. Budington, Expenses for Executive Committee, meeting 1932	4.55
W. H. Alexander, Expenses for 1933 Meeting	20.00
Transferred to Trust Account (by Bank, during Bank Holiday)	37.65
Rose McCabe, Secretarial Services for the Treasurer	33.50
B. S. Meyer, Business Manager, Ohio Journal of Science, (1932 Proceedings of the Ohio Academy of Science)	321.17
Checks returned	20.00
Tax for writing checks	.34
Total Disbursements	$1,007.45

Respectfully submitted,

A. E. WALLER,
Treasurer.

Auditor's Report.

COLUMBUS, OHIO, April 10, 1933.

Professor A. E. Waller, Treasurer,
The Ohio Academy of Science, Columbus, Ohio.

DEAR SIR:—Complying with your instructions, I have completed my examination of your records of The Ohio Academy of Science and find the receipts for the period from April 25, 1932, to April 1, 1933, of $1,223.41, to be correctly accounted for in the statements of The Huntington National Bank, depository for the Academy. Disbursements of $1,007.45 for the same period have been verified by cancelled checks and voucher charge slips of the Bank and found to be correct. The cash position for the period is as follows:

Cash Balance April 25, 1932		$222.19
Cash Receipts—April 25, 1932, to April 1, 1933	$1,223.41	
Cash Disbursements for same period	1,007.45	
Increase Cash Position		215.96
Cash on hand April 1, 1933		$438.15

Since the dates of payment of members dues were missing in a few of the accounts it was not possible for me to verify exactly the dues of $913.00 as shown in Treasurer's report. I feel certain, however, that all receipts have been properly accounted for.

Respectfully submitted,

JAMES P. CORNETET,
Certified Public Accountant.

Report of the Executive Committee.

By WILLIAM H. ALEXANDER, *Secretary.*

ATHENS, OHIO, April 14, 1933.

To the Ohio Academy of Science:

Your Executive Committee begs to submit through its Secretary the following report of its transactions during the year ending with this meeting, viz.:

The committee has held three meetings as an executive committee and has met in joint session with the Vice-Presidents of the Academy as a Committee on the Election of Fellows.

The first meeting of the Committee was held on October 29, 1932, at the office of the Secretary, with all members present, and by invitation Dr. Herbert Osborn, Editor of the Ohio Journal of Science, and Dean C. G. Shatzer, former chairman of the Committee on Junior Scientific Endeavor. The discussions of the various matters that came before the committee resulted in the following conclusions:

1. That owing to the reduced funds in the treasury the Editor of the Journal should take seriously into consideration the question of reducing the number of pages of the Journal.

2. That (and for the same reason) the publication of abstracts of papers presented at the Annual Meeting of the Academy should be omitted from the published Proceedings, for the present at least.

3. That notwithstanding the obvious merits in the Junior Scientific Endeavor movement as revealed in the fine efforts and report of Dean Shatzer, it was the unanimous opinion of the Committee that owing to a lack of funds to meet and overcome the practical difficulties obviously inherent in the work, as pointed out by Dean Shatzer, the only thing to do is to hold the matter in abeyance for the present at least. And the Committee so recommends. (See p. 290, Proceedings 1932.)

4. Regarding the matter of an "Academy accounting system and custody of funds," etc., referred to this Committee by vote of the Academy at the last Annual Meeting (Proceedings 1932, p. 267), the Committee found itself quite in harmony with the views of the Treasurer as to the need of a better method of auditing the accounts and accordingly authorized the Treasurer to enter into negotiations with the proper department or officials at the Ohio State University and solicit their assistance in devising a suitable method to recommend to the Academy for its approval.

5. As to the question raised by the Chairman of the Library Committee relative to the disposition of funds received from the sale of Proceedings, etc. (see p. 270, Proceedings 1932), the Executive Committee recommends that these funds be credited to the Academy.

6. As to the place for holding the Annual Meeting for 1933 the Committee decided unanimously to accept the offer of the Ohio University, Athens, and the exact date to be left with the Secretary after further negotiations with the Ohio University, assuming some date during or very near the Easter Holidays would be finally agreed upon.

7. The Secretary was instructed to correspond with the officials of the West Virginia Academy of Science with a view to a joint meeting of the two academies if such was thought desirable and practicable and provided further such a joint meeting would be agreeable to the Ohio University.

8. President Budington was unanimously elected to represent the Ohio Academy on the Council of the American Association for the Advancement of Science and on the Academy Conference at the Atlantic City meeting.

9. A subcommittee, consisting of Prof. Alpheus W. Smith, Chairman; President Budington and Secretary Alexander, was named to investigate the feasibility and advisability of the Academy sponsoring the broadcasting of a series of scientific talks or addresses and report back to the full committee at its next meeting.

The second meeting of the committee was held in the office of the Secretary on January 6, 1933, with four of the five members present. At this meeting the following items of business were transacted, viz.:

1. The Treasurer reported progress in his negotiations with Ohio State University authorities relative to a system of auditing and accounting. He was requested to continue his efforts.

2. The Secretary read a letter from the Secretary of the West Virginia Academy of Science relative to a proposed joint meeting of the two academies which said in part: "Our Academy was not in favor of meeting out of the State this year. * * * Perhaps in the future, when the Academy members feel they can afford to travel a little further, we can arrange for a joint meeting."

3. The Secretary reported for the sub-committee on the series of proposed radio talks that Professor Smith had secured the generous co-operation of the Ohio State University in putting on one talk a week from station WEAO and that he (the Secretary) had met with a ready response on the part of members to give such talks and that the series would begin at 7:45 P. M. on January 6, 1933, President Budington being the first speaker. (See Appendix B.)

4. A petition signed by 68 prominent chemists of the State (see Appendix A) asking permission to organize a *Section of Chemistry of the Ohio Academy of Science*, was then laid before the Committee, carefully considered and by a unanimous vote the permission was granted subject to ratification by the Academy, which action we now recommend. The Executive Committee requested Professor William Lloyd Evans, Ohio State University, to serve as the Acting Vice-President of the Section of Chemistry until the annual meeting of 1933.

5. The Committee voted that we should have at least one invited speaker for the annual meeting. Several names were suggested and the Secretary was instructed to correspond with them and make such selection or selections as to him seemed best or possible.

The third meeting of the Executive Committee was a joint meeting with the Vice-Presidents as a Committee on the Election of Fellows, a full report of which will be made later.

The fourth and last meeting was held last evening at Hotel Berry, Athens, Ohio, when it was agreed that:

1. The matter of continuing the series of radio talks should be left with incoming Executive Committee.

2. Membership in the "Save Outdoor Ohio Council" should be continued.

3. That in order to provide for a suitable accounting system, *Section 3, Chapter V of the By-Laws* of the Academy should be so amended as to provide for the audit of all the financial accounts of the Academy by a competent accountant, and that the fiscal year be the calendar year instead of from annual meeting to annual meeting as at present.

4. That the duties now performed by the Publication Committee and the Special Committee on Relations might well be combined under one committee.

5. That there should be a re-statement of the fourth recommendation of the Joint Committee (Publication Committee and Special Committee on Relations) relative to paying for the printing of the Proceedings Number of the Journal. (See p. 287, Proceedings 1932.)

Report of the Publications Committee.

(Informal.)

OBERLIN, OHIO, April 11, 1933.

Mr. W. H. Alexander, 8 East Broad Street, Columbus, Ohio.

DEAR MR. ALEXANDER:—I am sorry to have to report that it will not be possible for me to attend the meeting of the Ohio Academy at Athens this week. Blake and Moseley report that they will also be unable to be present. That will give the Publications Committee a zero for attendance and will make it impossible for a report to be presented by the Publications Committee.

As a matter of fact, the Committee has nothing to report, for its activities have been nil. You have been so good as to see through the press the Proceedings of the last annual meeting and arrange for its publication in the Ohio Journal of Science. Besides the Proceedings there have been no publications by the Academy during the current year. May I ask you to make whatever report seems necessary on the publication of the Proceedings. It seems too bad to burden you with anything more than you already have to carry, but your shoulders are broad, your efficiency is equal to anything, and your kindness is proverbial, so I add another to the impositions which are continually being placed upon you.

With best wishes, I am

Sincerely yours,

FREDERICK O. GROVER,
Head, Department of Botany.

Report of the Trustees of the Research Fund.

COLUMBUS, OHIO, April 1, 1933.

To the Ohio Academy of Science:

As in the preceding year, no grants to individuals have been made, as it seemed desirable still to hold the balance available for possible readjustments of the invested fund. The following summary of the account for 1932–33 shows an invested fund of $1,737.50 and a balance in uninvested account subject to check of $228.36.

SUMMARY OF ACCOUNT, 1932–33.

RECEIPTS.	
Balance from checking account, April 22, 1932	$ 137.86
Interest receipts from invested funds	90.50
Total	$ 228.36
BALANCE.	
Balance in checking account	$ 228.36
SUMMARY OF ASSETS.	
Invested Funds, Bonds and Certificates at face or cost	$1,737.50
Uninvested bank balance, in Ohio National Bank	228.36
Total	$1,965.86

The interest payments on bonds which were temporarily suspended have been renewed on a reduced interest basis, and it is believed that payments of interest may be expected regularly hereafter. Since there is now a small balance of uninvested funds we may consider the granting of some small sums for research projects and, unless the Academy favors further building up of the research fund, the Trustees will be ready to receive requests for grants during the coming year.

It may be noted that the interest payments for the year have amounted to a little more than 5% on the invested fund.

(Signed) HERBERT OSBORN, Chairman,
GEO. D. HUBBARD,
L. B. WALTON,
Trustees.

Auditor's Report.

COLUMBUS, OHIO, May 13, 1933.

Mr. William H. Alexander, Secretary,
The Ohio Academy of Science, Columbus, Ohio.

DEAR SIR:—I have completed my Audit of the Research Fund of the Trustees of The Ohio Academy of Science and find the same to be correct. The balance on deposit in The Ohio National Bank of $228.36 has been verified and found correct. The invested funds of $1,737.50 are found to consist of $1,300.00 of Fort Hayes 7% Bonds maturing October 15, 1934, and 25 shares of BancOhio Capital Stock.

The 25 shares of BancOhio were purchased November 27, 1931, at $17.50 per share. The market quotation of this stock today is $10.00 per share. There is no public market on the Fort Hayes Bonds that I have been able to find, which, perhaps is somewhat due to the proposal and plan as outlined in a letter of March 8, 1932, by the Bondholders Protective Committee. Briefly this plan was to issue Sinking Fund Bonds bearing 5% interest dating the issue January 1, 1932, and maturing the Bonds January 1, 1947.

There is undoubtedly a limited market for these Bonds today and I would suggest that some consideration be given the possibility of disposing of your holdings in exchange for other investments more readily salable and with possibilities for a more rapid recovery in value.

Respectfully submitted,

JAMES P. CORNETET,
Certified Public Accountant.

Report of the Library Committee.

COLUMBUS, OHIO, April 12, 1933.

To the Ohio Academy of Science:

There is little to report this year. The routine work of keeping the mailing list correct, of taking care of the few sales, of claiming the issues of the exchanges that somehow failed to arrive, and of posting issues of our publications to replace those which did not reach their

destinations, have constituted the greater part of the work which has been done during the past year.

Fourteen new exchanges have been secured. One of them is a joint publication of two state academies, Colorado and Wyoming.

The privilege of withdrawing books from the Ohio State University Library is called again to the attention of the members of the Academy. It is learned each year that some of the members, especially the newer ones, do not know that they are entitled to draw out books as individuals if they live at a distance from a college or university library. For those who are associated with a college it is preferred that they draw books through their own library on the inter-library loan plan. There is much material in our library that surely could be of use to the members of the Academy if they would use it.

The sales of publications have been disappointing this year, only slightly more than twenty-five dollars. As the present incumbent has had six good years with the sales ranging from sixty-three dollars to eighty-nine dollars, this seventh year should also have been a year of plenty. It is to be hoped that there will not continue to be six or seven lean years.

As the financial report is so little this year, the chairman of this committee was interested to learn the amounts of former years and found that ten years ago the sales amounted to practically the same as they have this year. A very brief history of the sales record may be of interest. No mention of selling publications is made in any of the Annual Reports of the Academy until 1904 when the Treasurer, Dr. Herbert Osborn, reported the sum of \$5.09 for "publications sold and miscellaneous receipts" during 1903–1904. Then Mr. W. C. Mills was appointed librarian, He reported \$21.43 for 1904–1905, and nearly fifty-nine dollars for his best year, 1911–1912. His total amount for the entire time that he was librarian, 1904–1914, was \$311.69. When the library of the Academy was deposited in the Ohio State University Library, Mr. Mills stated in his last annual report that for many years the sales had not begun to pay the postage necessary for mailing the special papers and annual reports, but now that the University had agreed to pay all postage, the funds received from the sale of publications would be another asset to the Academy. From 1915 to 1925, when the Main Library of the Ohio State University had charge, the sales amounted to \$252.42 for Mr. C. W. Reeder's nine years, and \$65.89 for Miss Alice McKee's two years, making a total of \$318.31 for the eleven years, which was nearly the same amount as the \$316.78 of the previous eleven years. From 1926 on to date the total amount of sales has been \$498.40. Adding the bank dividends of \$32.89 onto this sum, there is a total of \$531.29. The complete total of all the sales of publications for the entire period of nearly thirty years is \$1,166.38. Of this amount, \$316.78 was used for postage, leaving the sum acquired since the Library took charge, of \$849.60, as an asset to the Academy. The original cost of publishing the Special Papers and the Annual Reports has not been taken into consideration. It is mainly the former that are desired by purchasers and all of them except the first two and the last two were published with funds from the Emerson McMillin research fund.

If we do not consider numbers 13 and 15, there is a plentiful supply of each Special Paper except numbers 4, 5, and 6, of which there are 38 copies of No. 4, "The Fishes of Ohio;" 67 copies of No. 5, "The Tabanidae of Ohio," and 28 copies of No. 6, "The Birds of Ohio."

Only 40 papers were sold this year as compared with 129 papers last year, and with 166 the preceding year. The same one which headed the list last year headed it again this year, "The Fishes of Ohio," and for the same reason, which was that they were sold at the Franz Theodore Stone Laboratory to the students of Dr. R. C. Osburn's fish class.

The following financial report is submitted:

RECEIPTS.

Cash balance on hand April 28, 1932	$ 71.55
Collected on 1931–1932 sales	.60
Sales for 1932–1933	26.65
Bank dividends for 1932	2.69
Total Receipts	$101.49

EXPENDITURES.

A. E. Waller, Treasurer, for sales, 1931–1932	$ 41.85
A. E. Waller, Treasurer, on account, 1932–1933 sales	5.00
Government two mill tax	.10
Total Expenditures	$ 46.95

Balance in bank April 12, 1933	$ 48.14
Cash on hand	5.40
Outstanding accounts	1.00
Expenditures, 1932–1933	46.95
Total	$101.49

SUMMARY OF ASSETS.

Unexpended balance on 1932–1933 sales	$ 21.65
Accumulated bank dividends, 1926–1932	32.89
Total Assets	$ 54.54

ANNUAL REPORTS OF PROCEEDINGS AND SPECIAL PAPERS. 1892–1931.

ANNUAL REPORTS.

First to Sixteenth	30 cents each
Seventeenth to Twenty-fourth and Twenty-sixth to Thirty-seventh	40 cents each
Twenty-fifth	75 cents
Thirty-eighth to Forty-first	50 cents each

SPECIAL PAPERS.

1.	Sandusky Flora. pp. 167. E. L. MOSELEY	60 cents
2.	The Odonata of Ohio. pp. 116. DAVID S. KELLICOTT	60 cents
3.	The Preglacial Drainage of Ohio. pp. 75. W. G. TIGHT, J. A. BOWNOCKER, J. H. TODD AND GERARD FOWKE	50 cents
4.	The Fishes of Ohio. pp. 105. RAYMOND C. OSBURN	$1.00
5.	Tabanidae of Ohio. pp. 63. JAMES S. HINE	50 cents
6.	The Birds of Ohio. pp. 241. LYNDS JONES	$2.00

7. The Ecological Study of Big Spring Prairie. pp. 96. THOMAS A. BONSER .....50 cents
8. The Coccidae of Ohio. I. pp. 66. JAMES G. SANDERS .....50 cents
9. Batrachians and Reptiles of Ohio. pp. 54. MAX MORSE .....50 cents
10. Ecological Study of Brush Lake. pp. 20. J. H. SCHAFFNER, OTTO E. JENNINGS, FRED J. TYLER .....35 cents
11. The Willows of Ohio. pp. 60. ROBERT F. GRIGGS .....50 cents
12. Land and Fresh-water Mollusca of Ohio. pp. 35. V. STERKI .....50 cents
13. *The Protozoa of Sandusky Bay and Vicinity. F. L. LANDACRE $1.00
14. Discomycetes in the Vicinity of Oxford. pp. 54. FREDA M. BACHMAN .....50 cents
15. *Trees of Ohio and Surrounding Territory. pp. 122. JOHN H. SCHAFFNER $2.00
16. The Pteridophytes of Ohio. pp. 41. JOHN H. SCHAFFNER .....50 cents
17. Fauna of the Maxville Limestone. pp. 65. W. C. MORSE .....60 cents
18. The Agaricaceae of Ohio. pp. 116. W. G. STOVER .....75 cents
19. An Ecological Study of Buckeye Lake. pp. 138. FREDERICA DETMERS .....75 cents
20. Flora of the Oak Openings West of Toledo. pp. 56. E. L. MOSELEY .....50 cents
21. The Cedar Cliffs Prairie Opening of the Cincinnati Region. pp. 36. N. MILDRED IRWIN .....60 cents

Address: MRS. ETHEL M. MILLER, Library, Ohio State University, Columbus, Ohio.

Respectfully submitted,

ETHEL M. MILLER,
Chairman.

Auditor's Report.

COLUMBUS, OHIO, May 8, 1933.

Mr. William H. Alexander, Secretary,
The Ohio Academy of Science, Columbus, Ohio.

DEAR SIR:—I have completed my audit of the statements submitted by your Librarian, Mrs. Ethel M. Miller, for the period ending April 12, 1933, and find them correct in every detail.

Verification of the cash position reveals $48.14 on deposit with the Buckeye State Building and Loan Company; $4.35 cash on hand; $2.05 in postage stamps. A total of $54.54.

In my audit of this fund I find the account of the Academy reflecting the deposited funds of $48.14 is carried in an Installment stock account, which, due to a recent ruling of Buckeye State Building and Loan Company cannot be transferred and is at the present time subject to restricted withdrawals of $10.00 per month. While this deposit is, in my opinion, in a sound institution, I would suggest it be gotten in a more liquid form should there be a demand for an amount exceeding the present restricted withdrawal of $10.00.

Disbursements during this period of $46.95 are properly evidenced by receipts from Professor A. E. Waller, Treasurer.

Respectfully submitted,

JAMES P. CORNETET,
Certified Public Accountant.

*Temporarily out of print.

Report of the Committee on State Parks and Conservation.

To the Ohio Academy of Science:

Your committee is pleased to report that certain definite steps have been made during the year that promise results of permanent value. A meeting of the committee was called for January 5, 1933, by Edward S. Thomas, on request of the Chairman, who was absent from the city. The following members were present: E. Lucy Braun, Edmund Secrest, Emery R. Hayhurst, E. S. Wickliff, Wilbur E. Stout, Roscoe W. Franks, and Edward S. Thomas. There were also present in an advisory capacity, by invitation of committee: Dr. E. N. Transeau, Dr. D. M. DeLong, Dr. C. H. Kennedy, Annette Braun and Robert L. Gordon.

Miss Lucy Braun and Mr. Thomas, State Representatives for Ohio of the Committee on the Preservation of Natural Conditions of the Ecological Society of America, presented an outline of the plans of that society for the preservation of natural biotic communities. The plan, in brief, is for the establishment of inviolate Nature Sanctuaries in suitable localities throughout the United States. Three classes of sanctuaries are proposed, of which only the third class is available in Ohio, since the first two classes contemplate areas in which the original flora and fauna have been undisturbed or practically so.

The following areas or habitats were suggested as desirable for Nature Sanctuaries by various members of the committee: Little Rocky Branch, Hocking County; various ravines along Queer Creek, Old Man's Cave State Park; Roosevelt Game Preserve; Scioto Trail Forest, 8,500 acres; Shawnee Forest, 30,000 acres, including interesting hilltop areas on the tops of the ridges; the spectacular ant mounds of Adams County near Lawshee; Jefferson Preserve; portions of the interesting habitats in the Illinoian drift plains of southern Ohio; Cedar Swamp, Champaign County; the Oak Openings west of Toledo; Adams County dry prairies; Rhododendron areas; Dean Forest; areas along the Lake shore, especially the few dune areas, such as at Bay Point; some of the school lands in Colerain Township, Ross County; West Sister Island, Lake Erie; Tamarack Bogs of northeastern Ohio—Fox Lake, Punderson's L.; some good Beech-Maple area, if any yet to be found; White Pine area, such as at Loudenville; a fine tract of Oak-Liriodendron forest six miles from Gallipolis; some of the canal beds still remaining; areas of wet prairie; the tamarack bog owned by the city of Akron near Lake Rockwell; Fox Lake; an undisturbed area, if any, in the Black Swamp region; a cove with fine Tulip Trees just east of Hanging Rock.

State Forester Secrest tendered his fullest support to the project of preventing damage to floral and faunal areas, and offered any portion of the state forest for the purpose which might be suitable, subject, of course, to the consent of the trustees of the board. He suggested that Little Rocky Branch of Pine Creek would make an ideal preserve, since it was relatively undisturbed and not frequently visited by the public. It was suggested that it would be advisable not to fence off any such preserve in the state forests or erect special signs, until adequate

warden service was available, in view of the fact that the state forest regulations already provide sufficient restrictions against vandalism.

Mr. Wickliff offered the co-operation of the Division of Conservation and suggested that since Roosevelt Preserve was now closed to the public, it would make an ideal area for the preservation of the native flora and fauna.

It was thereupon moved, seconded and carried that the Division of Conservation be invited to make a sanctuary of the Roosevelt Preserve, and Mr. Wickliff was requested to present such invitation to the Conservation Council.

The Academy has been represented on the Save Outdoor Ohio Council by Dr. Waller and the chairman of this Committee and certain legislation sponsored by the Council is still awaiting action in the legislature. While some specific items of special interest to our Academy have apparently been overlooked, several of the bills, if enacted, will prove of advantage in promoting conservation.

Respectfully submitted,

E. LUCY BRAUN,
ERNEST J. CARMAN,
ROSCOE FRANKS,
EDMUND SECREST,
EMORY R. HAYHURST,
E. L. WICKLIFF,
WILBUR STOUT,
E. S. THOMAS,
HERBERT OSBORN, Chairman,

Report of Committee on Election of Fellows.

ATHENS, OHIO, April 15, 1933.

To the Ohio Academy of Science:

The Committee on the Election of Fellows met at 6:45 P. M., April 14, 1933, at Hotel Berry, Athens, Ohio, with ten members present, three absent. The following members of the Academy whose nominations were in proper form and accompanied by satisfactory documentary evidence of the nominee's scientific achievements, received the required three-fourths vote of the Committee and were accordingly declared duly elected to Fellowship in the Academy, viz.:

DAVID DIETZ
RUSH ELLIOTT
ROBERT A. KEHOE
RODERICK PEATTIE
WILLIAM C. STEHR

Respectfully submitted,

WILLIAM H. ALEXANDER,
Secretary.

Report of the Membership Committee.

ATHENS, OHIO, April 15, 1933.

To the Ohio Academy of Science:

Your Committee on Membership submits the following applications in due form and recommends the election of the applicants to membership in the Academy, viz.:

BATTELLE MEMORIAL INSTITUTE, 505 King Avenue, Columbus.
BENTLEY, W. B., Ohio University, Athens. *Chemistry.*
BRANSON, WENDELL, 15 Franklin Avenue, Columbus. *Biology.*
BURHANS, NATHANIEL C., 1105 W. Lane Avenue, Columbus. *Geography.*
BUSCH, K. G. A., 2424 Sherwood Road, Columbus. *Chemistry; Geology.*
CUNNINGHAM, HARRY A., 320 E. Erie Street, Kent. *Biology; Science of Education.*
CURTIS, GEORGE M., 4690 Sunbury Road, Columbus. *Medical Sciences; Biological Sciences.*
DOAN, CHARLES A., 324 Fallis Road, Columbus. *Medical and Biological Sciences.*
EVERHART, W. A., Denison University, Granville.
FERNELIUS, W. CONARD, 2084 Neil Avenue, Columbus. *Chemistry.*
GULLUM, FRANK B., 128 Lancaster Street, Athens. *Chemistry.*
HOLLINGSWORTH, MARION, Dept. of Chemistry, O. S. U. *Chemistry.*
HOOD, G. RAYMOND, 516 S. Main Street, Oxford. *Chemistry (Geology).*
HORN, ROBERT C., 505 Locust Avenue, Zanesville. *Physics.*
INMAN, ELIZABETH, Bowling Green. *Botany; Biology.*
JOHNSTON, HERRICK T., 321 E. Twentieth Avenue, Columbus. *Chemistry; Physics.*
LEUBA, CLARENCE, Antioch College, Yellow Springs. *Psychology.*
MATHENY, WILLIAM A., Box 528, Athens. *Botany.*
MOYER, HARVEY V., Department of Chemistry, O. S. U. *Chemistry.*
PALMER, MAURICE B., Kent State College, Kent. *Chemistry; Physics.*
ROTHEMUND, PAUL (W. K.), Antioch College, Yellow Springs. *Chemistry; Medicine.*
SINNETT, RALPH V., 95 Oak Hill Avenue, Delaware. *Chemistry.*
SONTAG, W. L., Yellow Springs. *Biology; Medicine; Psychology.*
THOMSEN, HARRY L., 207 E. College Street, Oberlin. *Geology; Astronomy; Chemistry.*
VERMILLION, MONROE T., 13 Mound Street, Athens. *Botany; Biology.*
WESP, EDWARD F., 1501 Neil Avenue, Columbus. *Chemistry; Physics.*
WOLFROM, M. L., Department of Chemistry, O. S. U., Columbus. *Chemistry.*
YOHE, G. R., 207 N. Franklin Street, Delaware. *Chemistry.*

Respectfully submitted,

J. PAUL VISSCHER, *Chairman,*
HOPE HIBBARD,
EUGENE VAN CLEEF.

Report of the Committee on Necrology.

ATHENS, OHIO, April 15, 1933.

To the Ohio Academy of Science:

The Committee on Necrology presents the following report:

EDO N. CLAASSEN.

A Charter Member of the Academy and one who took a very active interest in its affairs for many years, Mr. Claassen died at Cleveland, July 12, 1932, at the very advanced age of 99 years. Born and educated in Germany, where he received a degree in pharmacy from the University of Göttingen, he came to Cleveland in 1867 and engaged in the

drug business. He was also city chemist of Cleveland for a number of years in the early 1880's. An able chemist, he contributed to research in various phases of this field and, among other discoveries, he is credited with the isolation of the bitter principle of cranberries.

Always interested in and conversant with various phases of biological work, his chief interest was in botany. He made extensive collections of plants and gave a series of some 10,000 specimens to the Western Reserve University. This collection, which has been made a memorial to him, is especially rich in grasses and liverworts.

During his long and active life, Mr. Claassen published over a hundred papers, of which 31 dealt with Ohio botany and nearly all of these have been published in the Annual Reports of the Academy or in the Ohio Naturalist or Ohio Journal of Science. The first of these publications is dated 1892, the last in 1924 when he was 91 years of age.

His quiet and sincere personality, his broad knowledge and his interest in the work of younger men were outstanding traits, and these in addition to his contributions to science, caused him to be highly appreciated during his forty years of association with the Ohio Academy of Science.

VICTOR STERKI.

Mr. Sterki was born in Soluthurn, Switzerland, in 1846 and died at his home in New Philadelphia on January 25, 1933, in the 87th year of his age. He studied at Munich and received the M. D. degree at Bern in 1873. He practised medicine in Switzerland until 1883, when he removed to New Philadelphia.

He was especially interested in Mollusca and became one of the best known students of the land and freshwater species in America. In all 52 of his publications deal with Ohio Mollusca. Most of this work was published in "The Nautilus," but 14 papers are to be found in the Annual Reports of the Ohio Academy, The Ohio Naturalist and the Ohio Journal of Science. The best known of these is "The Land and Freshwater Mollusca of Ohio," Special Paper No. 12 of the Ohio Academy of Science.

Mr. Sterki became a member in 1894 and contributed many papers at the annual meetings. In 1909 he was appointed Assistant Conchologist at the Carnegie Museum at Pittsburgh and later was advanced to Associate Curator of Mollusca, a position which he retained until advancing years and ill health compelled him to retire. His extensive collections are deposited in the Carnegie Museum. He was an enthusiastic collector and a careful and diligent worker, and has made a definite and permanent place for himself in the conchology of America.

F. L. ODENBACH.

The Rev. Frederick L. Odenbach, S. J., a member of the Academy since 1899, died at Cleveland on March 15, aged 75 years. For the past forty years he had been meteorologist and seismologist at the John Carroll University in Cleveland. The influence of Father Odenbach in this field of science was such that by his initiative seismological stations were installed at fifteen Jesuit institutions in the United States

and Canada from 1909 to 1912. His work attracted wide interest and he was well known in his chosen field of research.

Miss Wilhelmine Werdelmann.

Miss Werdelmann, night supervisor of the University Hospital at Ohio State University, died on February 23, 1933. She was born in Dresden, Germany, served as nurse in that country during the world war and came to America about ten years ago. After a time she took special training and was graduated from the University in 1928. Being a woman of unusual ability, she was rapidly advanced and for the past two years she had entire charge of the hospital during the night. She became a member of the Academy at the 1932 meeting.

E. B. Williamson.

Edward Bruce Williamson, of Bluffton, Indiana, a member of the Academy since 1897, died at Ann Arbor, Michigan, February 28, 1933, aged 55 years. He was well known to the entomologists of the world, especially as an authority on the Odonata. He was a nephew of Prof. W. A. Kellerman, who contributed so largely to systematic botany in Ohio.

He was graduated at Ohio State University in 1898 at the age of 20, was an assistant curator at the Carnegie Museum of Pittsburgh for a year, taught science in the high school at Salem, Ohio, 1899–1900, and was fellow in zoology at Vanderbilt University the following year.

Though for nearly thirty years the banking business absorbed a large share of his time, he never ceased his scientific work and publications of real worth flowed in continuous series from his pen. His short vacations from business were all spent in the field and he had made collections of dragonflies in Guatemala and several parts of South America as well as in different regions of the United States. He was an indefatigable worker, applying himself at his research usually far into the night.

Since 1930 Mr. Williamson spent the winter months as Curator of Odonata at the Michigan Zoological Museum at Ann Arbor, where his very extensive collections and exhaustive library on Odonata are deposited. The summer was spent at his Iris farm at Bluffton, Indiana, where he had produced many of the finest varieties of Iris developed in the country.

He had a wide knowledge in many fields of thought, and an enthusiastic interest in all phases of natural history which was so contagious that no one could come into contact with him for even a short time without feeling it.

His writings are published chiefly in entomological journals, though several of his earlier papers appear in the Annual Report of the Ohio Academy and the Ohio Naturalist.

Raymond C. Osburn,
Committee on Necrology.

Report of the Administrative Board of the Ohio Journal of Science.

To the Ohio Academy of Science:

Two meetings of the Administrative Board have been held since the submission of the last report.

The first meeting was held November 12, 1932. Present were Messrs. Rice, Transeau and Blake of the Board; Herbert Osborn, Editor, and B. S. Meyer, Business Manager. At this meeting Professor Osborn tendered his resignation as Editor, which was accepted with regret by the Board. Dr. L. H. Snyder, the incumbent Associate Editor, was unanimously elected as Editor for the coming year. All of the other officers of the Journal and the Administrative Board were re-elected for the coming year, except that the position of Associate Editor was left vacant. A list of these officers was included in the preceding report of the Board. Other business at this meeting was of a routine nature.

The second meeting of the Board was held April 8, 1932. Present were Messrs. Rice, Transeau and Blake of the Board; L. H. Snyder, Editor, and B. S. Meyer, Business Manager.

It was agreed by the Board that the Editor should be authorized to accept papers for publication in the Journal out of their order of acceptance, if the sponsors of the papers would defray half of the cost of publication.

Motion was carried by the Board to transmit to the Academy the recommendation that the present arrangements for the printing of the Proceedings by the Journal be continued in force, (page 287, 1932 Proceedings).

Motion was carried by the Board that the Academy act definitely on the recommendations of the Joint Committee on the relation between the Academy and the Journal (pp. 287–288, 1932 Proceedings). No record of any action by the Academy is included in last year's Proceedings.

The following financial report was presented by the Business Manager and audited by a committee consisting of E. L. Rice and E. N. Transeau:

FISCAL YEAR 1932.

(As of March 15, 1933.)

RECEIPTS.

Balance from 1931	$ 336.13
Annual University Allowance	900.00
Dues from Ohio Academy of Science	600.00
Subscriptions	100.40
Authors' Payments for Plates	167.93
Sales of Back Numbers	12.00
	$2,116.46

EXPENDITURES.

Spahr & Glenn Co., Printing first four numbers, Vol. 32	$1,437.90
Envelopes and Office Supplies	31.85
Bucher Engraving Co	335.34

James R. Geren, Postmaster	131.67
Clerical assistance	8.00
Purchase of back numbers of Journal	1.00
Federal check tax	.44
	$1,946.20
Balance on hand, March 15, 1933 (Huntington National Bank, Columbus)	170.26
	$2,116.46

All actions of the Administrative Board during the past year have been unanimous.

Respectfully submitted,

B. S. MEYER,
Secretary of the Board.

Report of the Nominating Committee.

ATHENS, OHIO, April 15, 1933.

To the Ohio Academy of Science:

The Committee on Nominations has the honor to submit the following:

President—E. LUCY BRAUN.

Vice-Presidents:

A. *Zoology*—NEALE F. HOWARD.
B. *Botany*—ORVILLE T. WILSON.
C. *Geology*—WILLIAM A. P. GRAHAM.
D. *Medical Sciences*—ROBERT A. KEHOE.
E. *Psychology*—RICHARD S. UHRBROCK.
F. *Physics and Astronomy*—RAY LEE EDWARDS.
G. *Geography*—RODERICK PEATTIE.
H. *Chemistry*—WILLIAM LLOYD EVANS.

Secretary—WILLIAM H. ALEXANDER.

Treasurer—A. E. WALLER.

Elective Members, Executive Committee—R. A. BUDINGTON AND JAMES P. PORTER.

Trustee, Research Fund—ALPHEUS W. SMITH.

Publications Committee—F. O. GROVER, J. E. CARMAN, S. W. WILLIAMS.

Library Committee—FREDERICK C. BLAKE.

Committee on State Parks and Conservation—EDMUND SECREST, H. C. SAMPSON AND EMERY R. HAYHURST.

Representatives on Save Outdoor Ohio Council—HERBERT OSBORN AND E. N. TRANSEAU.

Respectfully submitted,

DWIGHT M. DELONG, *Chairman*,
ARTHUR T. EVANS,
EDMUND M. SPIEKER,
SHIRO TASHIRO,
HORACE B. ENGLISH,
F. G. TUCKER,
EUGENE VAN CLEEF,
Committee.

Report of the Committee on Junior Scientific Endeavor.

By C. G. Shatzer.

The Ohio Academy of Science in accord with a recommendation of the committee offered at the April, 1932, meeting, dismissed the committee. The project of encouraging Junior Scientific Endeavor was referred to the Executive Committee for review with power to act.

An opportunity has presented itself to the dismissed committee to promote the project. R. L. Baird and C. G. Shatzer conferred with Mr. B. O. Skinner, Director of the Ohio State Department of Education, and found that he is very much interested in the project. As a result of this conference it is recommended:

1. That a central office be established where high school students may secure information concerning their nature discoveries and to which they may send material for identification.
2. That Mr. Skinner be informed that his offer to print and distribute copies of a 4- or 8-page bulletin is greatly appreciated and that immediate steps will be taken to place such a bulletin at the disposal of high school students.
3. That a member of the Academy be sought who will volunteer his services to conduct the office and prepare the bulletin suggested in Item 2 for the year 1933–34.
4. That specialists in the various fields of science be sought among the members of the Academy who will co-operate with the director in preparing the bulletin material and identify specimens submitted by the students.
5. That the Ohio Academy of Science appropriate an amount not to exceed $100.00 to defray postage charges for the director's office, transportation of specimens, cost of paper for the bulletin, etc., for the year 1933–34.

Memorandum.

(Supplemental to the Report of the Committee on Junior Scientific Endeavor.)

Re. visit of Mr. R. L. Baird and Mr. C. G. Shatzer to Mr. B. O. Skinner, March 29, 1933.

Re. co-operation between the Ohio Academy of Science and the Ohio State Department of Education in promoting Junior Scientific Endeavor.

The attitude of Mr. Skinner was excellent.

1. Mr. Baird proposed to Mr. Skinner that a central office be established where high school students might seek information concerning their discoveries and to which they might submit material for identification. Mr. Skinner indicated that the funds are not now available to aid in the support of such an office, but expressed the opinion that favorable consideration would be given the matter when funds were available.

2. Mr. Skinner agreed that the Department of Education would finance the printing and the mailing of a monthly bulletin of high school scientific work to the high schools of the state, if the Ohio Academy of Science would provide the above information, prepare the articles for the bulletin and supply the paper.

3. The Academy ought to grant Mr. R. L. Baird the authority to organize the information center and to secure the co-operation of specialists in the Academy to aid him in identifying material and preparing the bulletin. Mr. Baird's experiences with high school students who are interested in nature studies suggest that this procedure will further greatly the Junior Scientific Endeavor project.

Report of the Committee on Resolutions.

ATHENS, OHIO, April 15, 1933.

THE OHIO ACADEMY OF SCIENCE desires to express to the President and other administrators of OHIO UNIVERSITY and to the members of the local committee its grateful thanks for the hearty and cordial welcome received by its membership at its forty-thiry annual meeting.

Respectfully submitted,

EDWARD L. RICE,
F. C. BLAKE,
(H. C. SAMPSON),
Committee.

Natural Gardens.

The ecological approach to the description of the flora of any region is not particularly new. However, Doctor Wells has a fresh style of writing which at the same time appeals to the educated reader and bears the close scrutiny of the plant scientist.

As the author states in his preface, "The first part of this popular book dealing with our natural gardens is devoted to a general account of the vegetation and habitat of each of the eleven major plant communities of North Carolina. In the second part, an original artificial key to the herbaceous wild-flower plants of the state is presented, accompanied by description of the genera and important species."

The work abounds in illustrations, mostly half-tones, well-chosen and faithfully reproduced. The publication of this volume at this time is made possible through the co-operation of the Garden Club of North Carolina, to whom the book is dedicated, and to the University of North Carolina Press. The latter is deserving of praise for the attractive presswork and substantial binding of a beautiful book.—R. B. GORDON.

The Natural Gardens of North Carolina, by B. W. Wells. xx + 458 pp. Chapel Hill, The University of North Carolina Press. 1933.

APPENDIX A.

A PETITION.

To the Executive Committee of the Ohio Academy of Science, Columbus, Ohio.

We, the undersigned chemists in the State of Ohio, make a common petition to your honorable body for permission to organize a *Section of Chemistry in the Ohio Academy of Science*, viz.:

NAME	INSTITUTION	ADDRESS
William Lloyd Evans	Ohio State University	Columbus
C. W. Foulk	Ohio State University	Columbus
W. S. Frame	Ohio State University	Columbus
M. L. Wolfrom	Ohio State University	Columbus
H. L. Johnston	Ohio State University	Columbus
Wallace R. Brode	Ohio State University	Columbus
Edward Mack, Jr	Ohio State University	Columbus
Cecil E. Boord	Ohio State University	Columbus
H. V. Moyer	Ohio State University	Columbus
J. E. Day	Ohio State University	Columbus
Marion Hollingsworth	Ohio State University	Columbus
Edward F. Wesp	Ohio State University	Columbus
G. Bryant Bachman	Ohio State University	Columbus
W. Conrad Fernelius	Ohio State University	Columbus
Wm. McPherson	Ohio State University	Columbus
Roy I. Grady	College of Wooster	Wooster
John W. Chettum	College of Wooster	Wooster
Wm. C. Dearing	College of Wooster	Wooster
Wm. M. Morgan	Mount Union College	Mount Union
L. A. Pappenhogen	Mount Union College	Mount Union
C. A. Morey	Findlay College	Findlay
Thomas W. Jordan	Findlay College	Findlay
Marion Shank	Findlay College	Findlay
M. P. Puterbaugh	Ashland College	Ashland
Paul H. Fall	Hiram College	Hiram
W. B. Bentley	Ohio University	Athens
D. R. Clippinger	Ohio University	Athens
J. R. Morton	Ohio University	Athens
F. B. Gullum	Ohio University	Athens
Clare Martin	Bowling Green State College	Bowling Green
W. E. Singer	Bowling Green State College	Bowling Green
Louis C. Veler	Bowling Green State College	Bowling Green
C. S. Adams	Antioch College	Yellow Springs
S. J. Broderick	Antioch College	Yellow Springs
P. W. K. Rothemund	Antioch College	Yellow Springs
J. W. Haldred	Antioch College	Yellow Springs
W. A. Hammond	Antioch College	Yellow Springs
John W. Barker	Wittenberg College	Springfield
A. F. Linn	Wittenberg College	Springfield
J. W. Morgan	Wittenberg College	Springfield
Henry S. Ciles	Wittenberg College	Springfield
E. D. Scudder	Youngstown College	Youngstown
W. C. Ebaugh	Denison University	Granville
W. A. Everhart	Denison University	Granville
Lottie E. Munn	Lake Erie College	Ashtabula
Gladys K. Wardwell	Lake Erie College	Ashtabula
K. G. Busch	Capital University	Columbus
Grover L. Orr	Capital University	Columbus
J. G. Ralston	Muskingum College	New Concord
P. E. Clark	Muskingum College	New Concord

NAME	INSTITUTION	ADDRESS
C. B. Rutenber	Kenyon College	Gambier
W. H. Coolidge	Kenyon College	Gambier
W. A. Manuel	Ohio Wesleyan University	Delaware
G. R. Yoke	Ohio Wesleyan University	Delaware
R. V. Sinnett	Ohio Wesleyan University	Delaware
Junia E. McAlister	Ohio Wesleyan University	Delaware
J. R. Harrod	Ohio Northern University	Ada
Robert C. Gibson	Ohio Northern University	Ada
H. C. Brill	Miami University	Oxford
C. W. Kreger	Miami University	Oxford
Carl N. Webb	Miami University	Oxford
August Fruehan	Miami University	Oxford
G. Raymond Hord	Miami University	Oxford
A. Lawrence Curl	Miami University	Oxford
C. F. Rumold	Kent State College	Kent
Maurice B. Palmer	Kent State College	Kent
A. W. Coven	Kent State College	Kent
Alfred B. Garrett	Kent State College	Kent
Clarence L. Cook	Kent State College	Kent
L. A. Weinland	Otterbein College	Westerville
A. J. Esselstyn	Otterbein College	Westerville

APPENDIX B.

RADIO TALKS.

The following is a list of the radio talks sponsored by the Ohio Academy of Science and given by members of the Academy through the generous courtesy of The Ohio State University Broadcasting Station, WEAO, each Friday, between 7:45 and 8:00 P. M. from January 6 to April 28, 1933.

January 6—President R. A. Budington, Oberlin College, Oberlin. Topic: *"Why Ohio is Interesting."*

13—Harlan T. Stetson, Perkins Observatory, Delaware. Topic: *"The Perkins Observatory as a Scientific Institution."*

20—James R. Withrow, Ohio State University, Columbus. Topic: *"What is Gasolene? From Whence Does it Come? How Manufactured, Tested and Controlled?"*

27—C. G. Shatzer, Dean, Wittenberg College, Springfield. Topic: *"The Geography of the Ohio Area."*

February 3—L. W. Taylor, Oberlin College, Oberlin. Topic: *"The Cosmic Ray."*

10—Allyn C. Swinnerton, Antioch College, Yellow Springs. Topic: *"Caves."*

17—Ondess L. Inman, Antioch College, Yellow Springs. Topic: *"The Green Leaf."*

24—Eugene Van Cleef, Ohio State University, Columbus. Topic: *"The Finns in Ohio."*

March 3—Charles A. Doan, Ohio State University, Columbus. Topic: *"The Romance of Modern Medical Exploration."*

10—Frank J. Wright, Denison University, Granville. Topic: *"The Proposed Shenandoah National Park."*

17—Allen C. Conger, Ohio Wesleyan University, Delaware. Topic: *"Snake Tales."*

March 24—JAMES P. PORTER, Ohio University, Athens. Topic: "*Recent Studies in the Psychology of Personality.*"

31—W. A. MANUEL, Ohio Wesleyan University, Delaware. Topic: "*Old King Coal.*"

April 7—EMERY R. HAYHURST, State Board of Health, Columbus. Topic: "*Air Conditions and Health.*"

14—DAVID C. WARNER, Executive Secretary, State Water Conservation Board. Topic: "*Water Conservation in Ohio.*"

21—ARTHUR W. LINDSEY, Denison University, Granville. Topic: "*Human Futures.*"

28—E H. JOHNSON, Kenyon College, Gambier. Topic: "*Science and Reconstruction.*"

BOOK NOTICES.

Hormones—the Tides of Life.

Knowledge of the complicated and interesting functions of the endocrine glands is increasing so rapidly that it is difficult for one not directly concerned in the experimental work to keep up with the advances. It is very much worth while, therefore, to have available this masterly and dispassionate account of the marvels of modern endocrinology. The layman will find it clear and readable, while the scientist will be struck with the technical implications which he can read into every chapter. It is essential that the biologist, at least, should avail himself of such guide-posts as this summary.—L. H. S.

The Tides of Life, by R. G. Hoskins. xi + 352 pp. New York, W. W. Norton and Co. 1933.

The Depths of the Earth.

This contribution to the knowledge of igneous rocks and the depth of the earth is divided into three main parts. Part I constitutes about a quarter of the book and deals with the various types and phrases of igneous rocks. Part II, which is about half of the book, discusses in detail Daly's theory of the make up of the earth. Part III, a little over a quarter of the book, considers the application of the general theory and certain rock clans. In Part II there is much speculation which is however "larded" with many facts.

To those familiar with Professor Daly's work little need be said. To those unfamiliar with his work, this is, like his other writings, both stimulating and valuable.—W. BERRY.

Igneous Rocks and the Depths of the Earth, by Reginald Aldworth Daly. xvi + 598 pp. New York, The McGraw-Hill Book Co. 1933.

Historical Geology.

The third edition of Schuchert's Historical Geology is for the most part rewritten, and in this edition Dunbar is the junior author. This edition does not supersede that of 1924, although it supplements the early edition in being more up to date; it is not as technical and not quite as advanced. The handling is such that details are grouped around principles so that the student has something upon which to use the varied facts. The authors and John Wiley and Sons have given us a text which is well handled on both parts and one which should enjoy such reception as was received by their earlier efforts.—W. BERRY.

A Textbook of Geology. Part II, Historical, by Charles Schuchert and Carl Dunbar. 3rd ed. vii + 551 pp. New York, John Wiley and Sons. 1933.

PRESIDENTIAL ADDRESS.

THE INNOCENCE AND GUILT OF SCIENCE.

ROBERT A. BUDINGTON.

The Ohio Academy of Science is now gathered for its forty-third annual meeting. If we may break away from its seriousness for the moment we may facetiously doff the present dinner occasion as its forty-third birthday party. At a time when an essentially unavoidable epidemic of township, municipal, and institutional centenaries is being celebrated, a mere 43 years makes our organization seem scarcely more than adolescent. This need not make us apologetic, however; quite otherwise, for no publicist, or other megaphone-manipulator of obvious facts fails to re-announce the well-worn doctrine that the hope of civilization is in the hands of youth. We confidently assert that the 143rd annual Academy meeting will be magnificent, far more consequential than the present occasion!

Personally, I cannot avoid wondering, very sympathetically, what subject upon which to address his audience the 143rd Academy president may select. On second thought, however, it is quite possible, probably probable, that wisdom and courage will have accumulated by that time to a degree resulting in the forbidding of this recurring speech imposition! But, unhappily for you, and for me, that date is too far in the future to get any amendment into control of the present occasion. We are both "in for it," for the next several minutes: you must swallow the "bitter pill"—and bravely attempt to keep lower jaws from dropping, as you do so, or ears from drooping!

In the earlier days, as our records show, when there was only a section devoted to biological subjects, an officer could frame up something to say along the special line of that interest. Gradually, as the accretion-like growth of the Academy has proceeded, the variety of sciences now gathered under its banner has so increased that a specialized subject is practically sure to bore a majority of our total group; hence, the Academy audience, gathered for an optional dinner, but consequently in essentially compulsory attendance on the speech following,

demands discussion of a comprehensive topic, one applying to all branches of science. I do not know when such a problem has been more successfully solved than it was by your last year's president, Professor Alpheas F. Smith. My temptation was to just read his address to you, again, this evening; we all would have been the gainers.

After not a little deliberation, mostly during last summer, I decided to adopt the subject I have, "The Innocence and Guilt of Science." For a long time I had felt repeatedly peeved, when, on occasion, in reading and in conversation, the spirit and service of science was subjected to a process of mud-throwing, and other shallow-minded abuse: everyone of this audience has felt similar resentment. Then, as the autumn came on, the newly invented words, "technocracy," "technocrat" and their ilk were foisted on an unprepared public, and the noise of their machinery became so deafening and offensive that my title was abandoned—permanently— as I thought. After a while, however—and as you know—the engineering departments at Columbia, and their collaborators, engaged in a wholly worth-while and admirable "Energy-Survey," found they had been caught unawares, sucked into a vortex; in other words, were being "strung" by a strangely clever statistical legerdemainist; they escaped from his clutches by firing him; Simeon Strunsky and others came to the rescue as meditators between the "Energy-Survey" and the public—and the situation was saved, or at least relieved. In my own predicament, as the term "technocracy" became less frequent and nauseating, courage gradually returned, my partial deliberations about the "innocence of science" were pulled out of the ashes, and are now being stuffed into your ears.

Before going further, let me undeceive anyone who imagines that science really needs any defense, or that I think so. The fact is, however, that we are often so illogical and temporarily confused that a kind of misunderstanding, or misconception of things creeps into our analysis of them. The speaker does not nurse the idea that it lies within the scope of his ability to "make the crooked ways straight, and the rough places plain." Hard work or thought after a hearty banquet like this is inadvisable (I take refuge in that theory), so I only aspire to augment your gastric satisfaction by offering a sort of after-dinner mint of not too objectionable a flavor.

The actual subject matter of science was present and has

descended to us from an infinitely remote past, of course. "Before the mountains were brought forth, or ever thou hads't formed the earth and the world, even from everlasting to everlasting," the elements of force, and of substance (if there is any such thing) were pursuing a behavior, a relationship of cause and effect, en masse, and as electrons and the like, which we little men are still puzzling over and as yet do not fathom or understand except in the most fractional way.

Science, as a *body of observed fact*, has also been in existence, "on the road," as we say, a very long time. In the sense in which the term is generally used, however, it can hardly be dated back to a beginning antedating the arrival of more-or-less intelligent man; for, like sound, it does not exist save as an experience of man, to which the term is applied. Needless to say, the *facts of nature*, all its bases and laws as we call them, have existed and been in operation ever since eternity began, if we may use that paradoxical phrase; while *Science*, which etymologically implies "things known," or knowledge, presupposes a knower; and any critically recognized, and organized, and appreciated body of facts we believe to be the possession and experience of only the one genus, Homo. Perhaps so far as evidence goes, we should concede to the Neanderthalers the credit for being the earliest observers, the earliest formulators of scientific knowledge, and the earliest ones to use what we think of as "applied Science;" in other words, they were the first "technocrats." The scientists among them recognized the seasons, no doubt, correlated with differing lengths of day and night or the dropping of leaves from deciduous trees as the frosts came on; the fact of gravity as revealed by weight of rocks and limbs and the running down hill of water; they knew the cleavage qualities of flint stones; the principles of balance and symmetry in their arrows and spears; they must have known much of anatomy of the animals they killed and ate; and doubtless something of the therapeutic values of the bark and leaves of particular kinds of trees, or herbs.

From still another angle, science, as *organized knowledge*, is thought of as emerging from the limbo of a less remote past, i. e., Homo, or Homines, made deductions, or practical applications along lines which have definitely come down to us in recorded language. Approximately, astronomy dates from Thales (650 B. C.?), who determined the length of the year and studied eclipses, and Anaximander (611 B. C.) who invented

the sun-dial. Anaximander is also one of the fathers of geography, in that he made a map of the world, however erroneous it was. He also took a hand at biological philosophy and framed up a "theory" of evolution. Pythagoras, also of the 6th century, B. C., reasoned the earth to be spherical, and, as a related subject, formulated many important mathematical theorems. Xenophanes, a contemporary of Pythagoras, was one of the earliest palaeontologists. Leucippus, whose dates are obscure but probably in the fifth century B. C., practically comprehended the atomic theory. Hippocrates the 2nd (460 B. C.) was the first real pathologist. Plato (429 B. C.) was one of the earliest to see the overlap of natural science on philosophy, and his pupil, Aristotle (384 B. C.) was the father of zoology, though he should also be accorded paternal relation especially to astronomy, including meteorology. Theophrastus, Aristotle's pupil, with his description of more than 500 species of plants, merits being called the "pater noster" of botany, while Archimedes, of the third century, B. C., the great student of inclined planes and thus the inventor of the screw, is one of the earliest devotees of mechanics.

Now, I have cited the above samples from the archives of scientific history purposely. Ah, those were the "good old days," when the motive of men who dealt with nature was pure and undefiled by any thought of the practical applications, the selling values of their discoveries, the temptation to take out patents, the dreams of recognition. Yes, those men, along with their contemporaries and followers for a few centuries, were real scientists: their interest was spontaneous, they were impelled by no inferior motives; their results were accepted as interesting, and, while not unchallenged, they were respected as scholars, as contributors to the general welfare of mankind. They studied Nature for its own sake; yes, "Those were the good old days!" I remind you of these men, their work and their place in the history of science because such reference furnishes a basis for a first articulation with the subject chosen for this talk.

No field of intellectual interest and endeavor has been subjected to such a deluge of earnest opprobrium and unqualified reproach, especially during the last fifteen years, as has science. At its feet has been laid the major responsibility for most of the present misery of mankind the world over. It is blamed for the very possibility of war, in large

measure, of course, because of the instruments of war—mechanical, chemical, bacteriological, and for the consequent endless complexity of international relations, indebtedness, and the uncertain character of the centuries ahead. It is blamed for the possibility of easy and rapid production, and thus of over-production; for the consequent unemployment situation and its accompanying human misery and staggering sociological problems; for the one-time disruption of the horse-breeding, wagon, and coach industries; later for the dismantling of unnumbered thousands of miles of electric railways, and now for the actual or approaching bankruptcy of our steam-railway systems. Science is held accountable for the relative ruin of the wool industry, the silk industry—while the recent revelation of the inherent possibilities in the nettle is proclaimed as fatal to half the total textile industry of the world. Large sheaves of further verdicts have been voted by the jury of our fellow-men, who have been bamboozled into thinking that the newly-born cult of technocrats is identical with the quiet associates in scientific research. This charge such a group as the Ohio Academy of Science, and all other similar organizations, as such or as individuals, vigorously resents. In saying this the defense is made, of course, on behalf of science as such, i. e., *pure science*, and on behalf of those who work in the spirit of Thales, and Hippocrates, and Leucippus: there is not in mind the application of scientifically established facts. True scientists "do not simply handle phenomena and describe or utilize them for some practical purpose, but explain them and show their correlations." This distinction has been further well pointed out by the late Thomas Hunt Montgomery.[1] He says:

"There is an enormous mental difference between the pure technologist and the pure scientist. We do not wish to imply, for instance, that the mind of the pure mathematician is higher than the mind of the engineer, for they are rather complemental; but the former is a scientist and the latter is not, in that the former seeks interpretations and the latter applications. A physicist is scientific so long as he keeps in mind explanations, but not when he simply constructs apparatus. In the same way there are two very different kinds of men interested in the microscope: one constructs it, but he is not a

[1] T. H. Montgomery: "The Aesthetic Element in Scientific Thought." Annual address by President, Texas Academy of Science, 1905.

scientist no matter how excellent a technician he may be; the scientist is he who patiently reasons and imagines with his eye at the ocular. There is an enormous difference between the technical expert and the scientific interpreter, for the first builds apparatus, makes use of phenomena; while the second tries to relate the phenomena and bring them together into certain broad generalizations. If there is a particular group which may be sharply defined, it is the group of minds interested in mechanical constructions. But it is an egregious error to rank these and scientists together: they are rather to be considered as entirely divergent both in work and aims. Scientists need to use apparatus, they are obliged sometimes to invent it; however, this apparatus is not of primary interest to them, but simply a tool: they look ahead, far beyond the means employed."

The foregoing thesis could be supported by innumerable illustrations. Columbus was completely possessed by the then-theory that the world is spherical, and that India could be reached by sailing westward as well as eastward; he saw many evidences in support of his theory; he wanted to establish the fact; he was not at all primarily interested in buying and selling Indian goods. He blundered into America, and proved it to be a fact; but no one thinks of blaming poor old Columbus for the rise and fall of Florida real estate, or for the administration of Jimmie Walker, even if they have occurred in the field of his discovery.

Among his innumerable other accomplishments, Benjamin Franklin flew his kite and toyed with lightning; but no poor devil has yet blamed him for the electric chair. Llewenhoek is not accountable for the inhuman use of bacteria in war; it's not the responsibility of the Wright Brothers that Lowell Bayles met his death at the Detroit Flying Field; Street (1794) committed no crime because your internal combustion engine responded to your foot as you got sleepy and smashed your auto against the telephone pole. Conversely, pure scientists must forego the credit which is due the inventors and the technologists for assembling their results into the innumerable forms which bless mankind. Their turning of laboriously-won scientific facts into such combinations and machine-forms as can serve useful ends is a wholly laudable occupation in its own right, but it is nevertheless true that the bona fide scientific investigator and the inventor of commercially saleable utilities are seldom combined in the same person. Insight and brilliancy

in one of these occupations is generally associated with mediocrity, or less, in the other. Nevertheless, it is probably true that a majority of people, not a few scientists included, fail to discriminate clearly between these two mental powers, and confuse the scientific investigator with the technologist; such are numb to the shifting of their intellectual currents, e. g., as they pass from the data of the physiological chemist and chick embryologist to those of the incubator manufacturer; from the laboratory of Professor John Abel, the isolator of epinephrin, to the factory for making chocolate-covered pills; from the laboratories of Klebs and Loeffler to the bottling department of Sharp and Dohme, or Parke Davis & Co.; from the synthesis of nitroglycerin to the dynamite factories of the DuPonts. The phenomenon of a combination investigator and inventor, as has been intimated, does occasionally occur as a "rara avis." One at once cites the accomplishments of Edison, and, long before him, Watt. But they are exceptions; as a rule, a man is Dr. Jeckyl, let us say, most of the time, and only momentarily Mr. Hyde, or vice versa.

Appealing again to an authority whose words will multiply the seriousness of my contention many-fold, let me quote from one of America's one-time great mathematical sons, Simon Newcomb.[2] At the opening of the International Congress of Arts and Sciences at the Universal Exposition in St. Louis (1904), he said, in commenting on the remarkable achievements of the 19th century, "The superficial observer, who sees the oak but forgets the acorn, might feel as though the special qualities which have brought out such great results are expert scientific knowledge and rare ingenuity, directed to the application of the powers of steam and electricity. From this point of view, the great inventors and the great captains of industry were the first agents in bringing about the modern era. But the more careful inquirer will see that the work of these men was possible only through a knowledge of the laws of nature, which had been gained by men whose work took precedence of theirs in logical order, and that success in invention has been measured by completeness in such knowledge. While giving all due honor to the great inventors, let us remember that the first place is that of the great investigators whose

[2]Simon Newcomb: "The Evolution of the Scientific Investigator." Opening address, International Congress of Arts and Science Universal Exposition, St. Louis, 1904.

forceful intellects opened the way to secrets previously hidden from men. Let it be an honor and not a reproach to these men that they were not actuated by the love of gain, and did not keep utilitarian ends in view in the pursuit of their researches. If it seems that in neglecting such ends they were leaving undone the most important part of their work, let us remember that nature turns a forbidding face to those who pay her court with the hope of gain, and is responsive only to those suitors whose love for her is pure and undefiled. Not only is the special genius required in the investigator, not that generally best adapted to applying the discoveries which he makes, but the results of his having sordid ends in view would be to narrow the field of his efforts, and exercise a depressing effect upon his activities. The true man of science has no such expression in his vocabulary as 'useful knowledge.' His domain is as wide as Nature itself, and he best fulfills his mission when he leaves to others the task of applying the knowledge he gives to the world."

It seems certain that scientists for all time will find one of their great exemplars and inspirations in Louis Pasteur. Unsurpassed in his scientific methods and accomplishments, he was likewise clear-thinking and high-minded in his devotion to his calling as investigator. The anecdote is familiar: offered the post of national supervisor of the silk industry at a then-princely salary per year, he declined, remarking that "such a step would be beneath the dignity and calling of a scientist." In modern parlance, he declined the calling into technocracy!

Whatever the guilt which may attach to the devises called instruments of war, whatever the results of machine invention and machine production, whatever the credit for undreamed speeds of communication and travel, whatever the future of radio and television and air travel—pure science can deny the guilt, and must forego the credit: her dealings were and are with the fundamentals, not with devisings, or recombinations, or with any of the honorable or wicked applications of the technocrats. Her province is with the facts of nature, the facts as they are, and were, untold ages ago: the facts as they were in the proterozoic, the palaeozoic, mesozoic, and cenozoic—long before man was here to observe, and longer before he invented anything.

And here our discussion blends into the second of three of the suits often brought against science, and about which

I am venturing to say something this evening. I refer to the specific or implied injury which scientific revelations have presumably done to different theories as to the nature of things, to long-held and preciously-valued personal philosophies, to ecclesiastical tenets or creeds, and consequently to human peace-of-mind and serenity. In so far as these last have depended on unfounded tradition, on mere usage, on superficial custom and habit, on superstition, on assumed revelation or inspiration in the field of ideas and beliefs, or on childish preferences, the contentions, i. e., the truths which have been established by science, may easily have been damaging, and deep wounds have hurt. The claim is usually advanced that science has concocted new facts, created laws de novo, out of its own powers and suitable to its own whims, in part, even, mischievously: it has toyed with the holy and sacred.

Such as see the matter thus must reflect that truth never changes, that the facts of science are not new, but eternal. They should slowly read the words of that poetic thinker who, in the opening words of a sonnet, has said:

> "Fear not to go where fearless Science leads,
> Who holds the Keys of God. What reigning light
> Thine eyes discern in that surrounding night
> Whence we have come . . .
> Thy Soul shall never find that wrong is right."

Put in other words, Ecclesiasticus need not worry about true scientists when he says, "That which hath been, is that which shall be: and that which hath been done, is that which shall be done: and there is no new thing under the sun." Scientists realize those facts already: they are simply that minority of people in general who feel the universe as a whole, and the minutiae, even to the size of electrons, to be genuinely interesting, and spontaneously give their time and strength, their lives, to finding out not new things, for there are none, but rather facts and relationships which have never been noticed or formulated before.

Thus while the scientific group in the first place resents the charge that its members are identical with the inventors and technologists, they, in the second place, vigorously resent the accusation that they create new forces, either as allies of the evil one or as collaborators with Almighty God. If they pray at all, it is in these words: "Open Thou mine eyes that I may see,"—the facts and the laws of the ages.

May I comment briefly on one other of the numerous criticisms not infrequently voiced as judgments against science? Rather than attempt to define or describe its nature, let me quote:

> "Every province of human interest has been brought under scientific classification, so that nearly all thought is now cast in 'general ideas.' This mode of thinking ignores individuality and sees in men and things only units of a class. For this reason, man is content with countless repetitions of the same form because his class idea is realized if it find in each object the few characteristics common to the group."

After citing a few examples by way of illustrating the foregoing contention, the commentator continues:

> "The world has been filled with these ugly forms made in the name of art, but they only bear witness that science has subdued the earth and now holds undisputed sway."

Then he adds as a separate paragraph:

> "Not only has it driven art into the background, but it has misrepresented its character."

And further on:

> "As I have said above, science is largely responsible for the widespread misconceptions of and indifference to art."

Let me at once add that the context of the above quotation fully explains that the writer does not mean that science is anything less than invaluable in its own way. He does mean that a body of students who have been disciplined in the precision methods of science are perhaps permanently injured as to their easy grasp of the highly visionary and imaginative practices which are vital to the artist. While trying to estimate the degree to which science is thus innocent or guilty as regards the fine arts, one must not forget that they have very different goals, at least when one has in mind the ultimate ambition of each. They do not pretend to be more than supplementary to each other, or to coincide save with respect to the most elementary beginnings of each. In all their separately diagnostic features, they strive and operate in very different fields,

with different ends in view, and make very unlike contributions to the mental and spiritual life of man. Art is characterized by breadth; generally by mass effects: it feeds the spirit of man, it works through his emotions, it amplifies his vision, and enlarges his soul by bringing his imagination into play. In a degree which statistical data could never secure, art lets a person attain a depth of feeling and appreciation which he would otherwise never experience.

The method of science, on the other hand, uses the mind as a tool, and by insistence on precision, on uniformity, on endless repetition and calibration, it brings about a state of mind which demands absolute and generally tangible truth, so far as this is humanly attainable: it engenders a dislike, an intolerance of haze and fog, of crude approximations, of half truths: dreams have little place in the disciple of science. In all these ways, then it must be conceded that the precision of science not only does not contribute to imaginative art, but, in a real degree, fosters a spirit which is inimical to art.

But, so far as guilt is to be assigned, so far as responsibility in the matter goes, is it not a matter of exchange of courtesies? Each of these fields of human interest and devotion says to the other, "The same to you, my dear Madam, or Sir!" This must have always been so: for even the deference which must be given to age hardly plays any part here, so ancient are both habits of human thought. The "general, inclusive effect" which art seeks, is hardly less than an abhorrence to science, and the exactness of science stands in the way of emotional art. The artist throws himself, his very soul, into the picture or the statue—his result is an alloy of his imagination, his vision, his materials and tools, and himself: on the other hand, the product of the scientist must be unbiased, impartial, impersonal, concrete.

Fortunately, human interests are hybrid to such degree that both art and science can be understood, and tolerated, and fostered in the make-up of the single individual. This is an instance of dual-personality, and caution should be exercised lest we let either the play of imagination and vision, or the insistence on accuracy be crowded out by, or confused with the other. It is fortunate, let me say further, that, "in spite of ourselves," we constantly experience and earnestly propagate the instinct which enjoys art on the one hand and simultaneously insists on scientific accuracy.

In a not too clear-cut way, I have tried to designate three of the commoner articulations with human affairs at which science is often called into court as an offender against the material, or intellectual, or spiritual welfare of human kind. As regards the first, we insist that there is a clear distinction between the investigator and discoverer of elemental truth, the truth which resides in the nature of things, and the person who makes permutations and combinations of the facts seen first by the true research worker, facts sought and found for their own sake. The technologist depends on the research worker for the secrets on which his devises rest, but the scientist may not be held responsible for either the good or evil, or the number of machines his brother-inventor creates.

As regards perversion of man's intellectual integrity, the accusers of the scientific observer as an agent in compelling them to modify their long-established opinions, in any field whatever, must always be admonished that America was here millions of years before Columbus discovered its shores: that there is nothing new under the sun: truth is eternal. It is not changed by shutting one's eyes to it, it is not created by any man, scientists or otherwise; but the soul of no man was ever washed and saved by stubborn attendance at the shrine of ignorance.

In the third place, while man's spiritual nature is not amenable to calculation or measurement, or reducible to formula, while it does leave solid ground and fact, and finds easier expression in the unconfined methods of art, where the limits imposed by experienced truth do not hold, we should not feel that art and science are contending for the same territory in human nature. Each in its place, art giving *vision*, and science *precision*, as has been said, are each vital constituents of man's every-day needs.

Finally, while fully aware that, as in the human body many a structure besides the heart or brain is easily a vital organ, so in the material, and intellectual, and spiritual departments of our lives we needs must feed in green pastures of various sorts, and draw inspirations and satisfactions from many different fields; yet, on the present occasion we pronounce our belief in the innocence of pure science and its motives: our emphasis is on the unlimited contribution which science makes to human thought and philosophy: and we endorse the words of John Dewey, when he says, "The future of our civilization depends upon the widening spread and deepening hold of the scientific habit of mind."

THE COST OF SOIL EROSION.*

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THE PROBLEM.

Unrestrained soil erosion is rapidly building a new empire of worn-out land in America: Land stripped of its rich surface layer down to poor subsoil, and land gullied beyond the possibility of practical reclamation. This wastage of the nation's most basic and indispensable asset is not merely continuing; it is speeding up. Over millions of acres the washing is becoming more rapid as the cutting away of the upper soil material lays bare the less stable substrata. Every rain heavy enough to cause water to flow across cultivated slopes and sparsely vegetated land removes part of the soil. Every one sees this in the muddied waters flowing away to the oceans, but few think of the material that discolors these flooded waters as soil material swept from the surface of the fields, where lies the most productive part of the land.

No other agency or combination of agencies remotely approximates the impoverishing effect of rainwater running wild across the slopes of America's farm lands. Three-fourths of the agricultural area of the nation is sloping enough to favor ruinous cutting away of the vital substance of the soil through the abrasive action of water. More than 100 million acres of the 350 million in cultivation have lost all or most of the precious material we call the topsoil. At least 160 million acres of the remainder are suffering in some degree. To date we have permitted the essential destruction of about 35 million acres of what formerly was largely good crop land, together with an enormous additional area of grazing land. This has been so deeply washed, so cut to pieces by gullying or so smothered with the products of erosion that it can not be reclaimed upon any practical basis by the average farmer. Much of it is permamently destroyed. Bedrock has been reached in countless places and deep gullies have torn asunder millions of sloping acres. All of this has been abandoned.

*Read at the General Meeting of the Ohio Academy of Science, April 14, 1938.

No other part of the western hemisphere has been so wasteful of its land resources as we of America. Probably no nation or race of all history has permitted its agricultural lands to go to waste so quickly. Other parts of the world have been ruined by erosion, but the lands were used for many centuries, even thousands of years, before their devastation was completed. The enormous impoverishment and destruction that we have permitted, even encouraged by lack of interest and foresight, has taken place with but two centuries of cultivation. Most of the depletion has been accomplished during the past fifty to seventy-five years. This has come about because of carelessness, ignorance and the physical peculiarities of our soils, rainfall and farm methods. With respect to land use, we have proceeded, and continue to proceed, without plans. We have used all kinds of land, occupying every degree of slope, indiscriminately for every conceivable purpose. There has been too little of orderly selection on the basis of adaptability and fitness, and almost no effort has been given to the vitally important matter of soil conservation. We have looked upon our vast domain of agricultural land as limitless and capable of enduring forever. Because the vast areas which have been made so poor that a man may spend his lifetime upon it without bettering himself or his farm will still grow something, we continue to produce an abundance of everything. The point of gravest menace is not a matter of producing a sufficiency of food. We shall be able to meet our requirements of both food and clothing for many years to come. But how? What is the menacing aspect of this evil of erosion?

The sore points deserving immediate serious consideration are these: Our best lands are largely in use and have been for some time. The area of these more favorable soils is steadily diminishing as the result of excessive rain-wash. Acreage yields are declining in spite of all the education and experimentation devoted to improvement of methods, and in spite of increased use of improved varieties, better seed, better machinery, high-grade fertilizers, soil-improving crops and irrigation, along with continuing abandonment of worn-out land for land still retaining its topsoil. Cultivation of erosion-exposed clay is more difficult and costly, and need for fertilization and building up of the soil is steadily increasing. Water flows across the impervious clay exposed by the stripping off of the mellow, humus-charged topsoil more rapidly to augment

floods. Tens of thousands of hard-working farmers already are subsoil farmers. Subsoil farming is an impoverishing type of agriculture. Although producing a large aggregate of crops, the average yields at this low level of soil productivity are so pitifully meager, there is but slim opportunity for the operator to get ahead, whether prices are up or down. Reservoirs that were built to hold water, not solid soil material, are rapidly filling with mud washed down from unprotected slopes; stream channels are silting up and overflows are becoming more frequent and destructive. Vast areas of alluvial land of extraordinary original productivity are being covered with infertile sand and gravel; large sums are required to protect the embankments and roadside ditches of our highways and railroads; and flood protection calls for the expenditure of ever increasing millions.

From every conceivable angle erosion is a devastating agency. It is the greatest thief of soil fertility. It steals not only the plant food contained in the soil but the whole body of the soil, plant food and all. When this productive material that required centuries in the building is washed out of fields it can not be economically hauled back, even where it is washed no farther than from the upper to the lower slopes of fields. That which passes down into the beds of streams and on out to the ocean is lost as irretrievably as if consumed with fire. Our best estimates indicate that erosion steals 21 times as much plant food as the crops take out of the land. That removed by crops can be restored, but that taken by water and wind can not be restored. It is a net loss of almost incalculable magnitude. The process is the principal cause of worn-out land. There can be no permanent cure of dangerous floods so long as this principal contributor to the evil remains unleashed. Higher and broader and more costly levees may be built, but they can not insure any permanency of protection with ever increasing volumes of water charging out of erosion-denuded uplands.

Our surveys and soil-loss measurements indicate that at least 3,000,000,000 tons of soil are washed out of the fields and pastures of the United States every year. The value of the plant food contained in this amounts to more than two billion dollars, on the basis of the cheapest fertilizers. Of this almost inconceivable wastage, the direct loss to the farmers of the nation is not less than $400,000,000 every year. This is

paid for in reduced acreage yields, increased cost of cultivation, fertilization and the growing of crops for the sole purpose of building up impoverished fields, in land abandoned, highways damaged, reservoirs, irrigation ditches and culverts choked with erosional debris, and accumulative thinning of the surface soil, the staggering cost of which is postponed until the last inch of soil is washed off.

In a single county of the old South Carolina Piedmont country, where farming has gone on for nearly two centuries, ninety thousand acres of once good farm land have been mapped as soil largely permanently destroyed by gullying. Countless ravines have chiseled to pieces former fields, exposing bedrock in numerous places, and all the soil has been lost. One farm of 1,004 acres, 200 of which were cleared of the virgin timber just after the Civil War, has not so much as a single acre of good farm land left in one place. No one lives on this once magnificent plantation. The palatial residence has tumbled to ruins. Silence pervades the desecrated acres; and all the surrounding country is much the same.

The same survey has shown in the same county forty-six thousand acres of stream bottom, formerly the best land of the entire state, which have been converted into swamp or so smothered with sand washed out of the hills that it no longer has value for crops. The stream channels are so choked that every rain of any importance sends flood waters over the alluvial plains.

Eight miles west of Lumpkin, Georgia, is the largest man-made gully of the western hemisphere. This chasm is 200 feet deep. It was started by the drip from the roof of a barn fifty years ago. Since then it has swallowed the barn, a schoolhouse, a tenant house and a graveyard with fifty graves. In addition to this huge gulch, there are thousands of others nearly as large. Altogether seventy thousand acres of the best farm land of the region have been permanently destroyed in one county by this irreparable devastation. To fill these gullies would require operations on the order of those employed in the construction of the Panama Canal. And yet, every one of them could have been stopped easily in their infancy, had the farmers known of the necessity and of the practical methods of procedure.

In five adjoining Alabama counties, 500,000 acres of formerly cultivated land, most of it once highly productive, have been

worn out with gullying and deep sheet washing. This is largely abandoned. Fortunately, much of it is growing up with pine trees. The growing of trees is the best possible use for such land.

In one county in southeastern Ohio, a soil survey made by the State and Government cooperating shows that nearly 200,000 acres of formerly cultivated land are no longer cultivated. Approximately half of this has been so terribly impoverished by erosion that it is no longer used for any purpose. First it was farmed, then turned over to pasture; now the fences have fallen down and only poverty grass, goldenrod and weeds are growing on it. This too could have been saved had the farmers known 50 or 75 years ago what we know today.

That the consciousness of the nation has not been aroused to the seriousness of this prodigiously costly evil is an ugly blot upon our record. In our textbooks we read of vast expanses of grass-covered prairies, of the buffaloes that grazed over these virgin grasslands; and we read of the enormous extent of our eastern forests and the fertile lands from which these have been cut. But we read little or nothing in these volumes of the desecration of these same areas following the breaking of the prairie sod and the cultivation of the lands that supported the forests; the destruction of millions of acres and the impoverishment and increasing impoverishment of a large proportion of the remainder. Are our children to believe that the present gullied and soil-skinned slopes of the nation represent normal conditions, or shall we tell them the truth in order to implant the germ of moral obligation to country and posterity which eventually would arouse that mobility of consciousness so vitally necessary for correction of our unwise land-use practices. If this is not done, if we continue as in the past cultivating steep lands and lands that wash away within a few short years following the first plowing, there can be but one outcome: Irreparable decline of the nation's most basic resource, its agricultural lands. This is not so much a prediction as an obvious physical eventuality based on the known depth of the productive topsoil and the known rates of soil removal and depletion by erosion.

At the moment there is widespread discussion of the evils of erosion and the necessity for controlling it. Some of these discussions seem to imply that all we have to do is to go out

and stop the wastage. We are fully aware of the fact that forests and grass and the thick-growing plants, such as lespedeza, alfalfa, sorghum and sweet clover, will largely reduce the washing; but we must continue to produce clean-tilled crops, as corn, potatoes, cotton and tobacco. It is in fields of these crops that the evil is so vicious and calls for immediate attention. There are various remedies and partial remedies. Some methods, effective on one soil occupying a given slope, are of little value for other soil conditions. For many kinds of land we have not yet ascertained the most economical and effective measures of control. The national program of soil erosion, described below, is striving with the greatest possible speed to develop the acutely needed methods for such lands.

In the discussions now going on a great deal of emphasis is devoted to gully control. Much good could be accomplished in this direction, especially in regions where gullying is widely prevalent; but on the whole necessity for gully control is of inconsequential importance in comparison with the need for control of sheet washing: That process of erosion which planes off a thin layer of soil with every rain heavy enough to cause water to flow across cultivated slopes. This process goes on so slowly that little attention is given it until infertile spots of clay subsoil and solid rock begin to make their appearance in fields, at which stage it usually is too late to do very much in the way of soil conservation, the soil having largely floated away in the direction of the oceans. Gullying usually begins at that stage of sheet washing when the soil is all gone.

Another unfortunate feature in connection with the erosion problem is that only a handful of soil specialists know how to distinguish sheet washing and to measure its effects. Practical capability in this important field calls for special knowledge of soil varieties, their morphological structure under virgin and cultivated conditions and their varying tendency to wash, as determined by soil type. Sheet erosion can be identified and its effects measured only by comparing eroded areas, soil layer by soil layer, with the original condition in woodlands and grass-covered areas. What will happen to a given area of a definite soil type if put into cultivation can be predicted only through this method of comparing and interpreting natural and abnormal soil conditions. What one kind of soil will suffer on a given slope frequently is entirely different from what will take place on another soil having

precisely the same gradient. This is one of the most fundamentally important aspects of the erosion problem, and without due consideration of these variables, erosion-control programs will suffer or come to nothing.

THE NATIONAL PROGRAM OF SOIL AND WATER CONSERVATION.

Finally recognizing the enormous cost of soil wastage by erosion and excessive loss of rainwater as runoff from unprotected cultivated slopes and from overgrazed ranges and pastures, Congress three years ago appropriated funds to begin a national program for studying the whole problem of erosion and for developing methods of control. The plan calls for accurate measurement of the losses of soil, water and fertility from various slopes undergoing different cropping treatments throughout twenty odd major regions of the nation where erosion is known to be a problem of enormous seriousness. To date, ten of these erosion experiment stations have been established.

At these stations every promising practical method for slowing down erosion is to be tried out on a field scale. Rates of soil loss and runoff are to be accurately determined from the different slopes planted to different crops and tilled in various ways. Terracing, strip-cropping, scarification of the land and other methods are being tried out, first on small plots and then in large fields, wherever the results have shown any promise of practical applicability. In some regions where livestock farming is important the land is being subjected to various conditions of grazing, in pastures containing a variety of grasses and other forage crops. The cheapest methods of reclaiming erosion-worn land are being determined, together with the cost. Various methods of gully control are being tested, using living dams of grass, trees, shrubs and vines, rock dams, dams made of poles, brush and other cheap materials. Conservation of the remaining soil, however, will be the prime endeavor of the program, rather than reclamation of depleted land.

As soon as the work at the stations gets well under way, every experiment of worth-while promise will necessarily constitute a demonstration. Field meetings are held on the farms at frequent intervals so that the farmers of the region may visit the station and see what is going on. The educational

phase of the work is being pursued in such manner as to acquaint the regional farmers with the precise meaning of erosion, its cost and the best methods for its control. There is no secrecy about any part of the program. Visitors are urged to come to the station from the very beginning of the work. They are urged also to bring to the specialists on the erosion farms any suggestions they may have which are based upon worth-while practices on their own farms, in order that every promising practice may be brought clearly out before all the farmers of the various regions.

To cite the work at one of these erosion farms: The Red Plains erosion station near Guthrie, Oklahoma, is located on the principal type of farm land in this highly erosive region, which comprise thirty-six million acres in Oklahoma and Texas. An erosion survey recently completed by the Oklahoma Agricultural College has shown that of the sixteen million acres under cultivation in that state, thirteen million acres are suffering seriously from erosion, nearly seven million acres of this having reached the stage of gullying. More than a million and a half acres have been ruined by deep washing and gullying during the past ten years. The annual cost of erosion to Oklahoma has been estimated by the state agricultural specialists to exceed $50,000,000, under normal price conditions with respect to farm commodities.

The work at the Red Plains station has shown that when the principal regional crop, cotton, is grown continuously, the loss of soil from the average slope amounts to 32.5 tons per acre per year, along with a loss of 14 per cent of the total precipitation as runoff. This means that under cotton only 30 years are required to wash off the entire depth of the surface soil, down to stiff clay subsoil, which produces less than half as much cotton as the uneroded topsoil.

The results show, on the other hand, that on precisely the same kind of soil and the same degree of slope only .03 tons of soil and 1.7 per cent of the precipitation are lost where grass is grown. In other words, grass reduced the soil loss by 1,080 times and the water loss by 8 times. Where cotton is grown in rotation with grain and a leguminous crop, the loss of soil is reduced by 350 per cent and the loss of rainfall by 23 per cent, as compared with the losses under continuous production of cotton.

Beyond this, terracing and strip cropping have very largely reduced the erosion. The farmers of the region are visiting the station daily, and more and more of them are putting into practice the soil-saving and water-conserving methods which have been worked out on soils like those on their own farms.

The work, such as is proposed for the erosion stations, should have been begun 50 or 75 years ago. At this advanced stage of our civilization we have not yet obtained the fundamental facts relating to the erosion problem, such as are vitally necessary for the carrying out of protective measures. If this work should be delayed the problem of erosion control would simply become progressively more difficult, more expensive and more discouraging. It is a problem that must be attended to now, not something that can be put off for future generations to solve. No moratorium can be declared against erosion. It must be fought with determination and effective implements. If we refuse to ascertain what these implements are, then the fight will be lost, or seriously retarded, farming on sloping land will become steadily less profitable and finally altogether hopeless. Floods will flow down the rivers of the nation in ever increasing volume. Cooperation from every thinking individual is needed in this combat. Let's remember that erosion is the most powerful agency affecting the physical character of the earth, and let's not forget that already we are very late in getting started the studies which should have been made first of all, the studies having to do with land use and the maintenance of soil productivity. We can not afford not to pursue this problem with all the energy at our command.

Human Reproduction.

Sex and its manifestations in man have been traditionally subjects of taboo. Science, which is coming into its own these days, recognizes no forbidden subjects, and acknowledges no taboos. This complete and extremely interesting account of the biology of sex in man fills a long-felt want, both for the biologist himself and the general public. Questions everyone has wondered about are answered here: hermophroditism, the hormones influencing sex, twinning, embryologic abnormalities and others. The book is a scholarly and dispassionate account of a difficult subject, and the author and publishers deserve a vote of thanks for the work. Abundant illustrations tell their story as no written words could, and add greatly to the value of the book.—L. H. S.

The Science of Human Reproduction, by H. M. Parshley. 319 pp. New York, W. W. Norton and Co. 1933.

THE STRUCTURE OF THE DIGESTIVE SYSTEM IN BOLITOTHERUS CORNUTUS.

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Several specimens of the forked fungus beetle (*Bolitotherus cornutus*) were obtained in April from woods in Hancock County, Ohio. At the suggestion of Dr. C. H. Kennedy a study of the internal morphology of this species was undertaken. All of the individuals collected in the spring were scattered underneath the bark of fallen logs on which was growing the large wood fungus (Polyporus). The beetles were in a state of hibernation. When the woods were again visited on July 30, specimens were obtained at the base of the fungus on stumps rather than on logs. The beetles brought into the laboratory in July were much more active than those taken in April. Larvae were present in the fungi both in April and July and although none were reared they were probably the larvae of this fungus beetle. A few eggs were laid in the laboratory by the beetles collected in July.

Bolitotherus cornutus, of the family Tenebrionidae, is common in Northeastern United States and Canada. The whole surface of the body and wing covers are very rough and there are two prominent horns on the prothorax, those on the male being much longer than those on the female.

These individuals are dull black in color and resemble a small piece of bark. They are approximately 9 mm. long and 5 mm. broad.

Specimens were kept alive in the laboratory by feeding them moist pieces of fungus. They were studied immediately after killing and the material which was to be used for sections was fixed with Kahle's fixative fluid as soon as the parts could be dissected in normal salt solution. Sections were cut from 6–10 microns in thickness. Some were stained with haemalum and fast green, others with Ehrlich's hematoxylin and Biebrich's Scarlet. The chitinous linings, cell walls, and cytoplasm were clearly stained by the fast green. The haemalum proved to be an excellent nuclear stain for this beetle.

The author wishes to express her thanks for the helpful suggestions and criticisms of Dr. C. H. Kennedy, under whose direction this study was made, also to fellow students for assistance in collecting and for suggestions in laboratory methods.

GROSS ANATOMY OF THE DIGESTIVE TRACT.

General Discussion.—The alimentary canal of *Bolitotherus cornutus* is a somewhat convoluted tube of approximately 25 mm. in length, that is almost three times the length of the beetle itself. It is divided into three chief regions, the fore-intestine (Stomodaeum), mid-intestine (Mesenteron or Ventriculus), and the hind-intestine (Proctodaeum).

The Gross Structure of the Fore-Intestine.—The fore-intestine is very short, being 3 mm. in length. It is composed of the pharynx, oesophagus, crop and oesophageal valve. (Plate I, Fig. 1.)

The *pharynx* extends from the mouth as a straight tube, having muscle attachments radiating out from its surface and connecting it with the head capsule.

The oesophagus continues as a narrow tube from the pharynx and terminates by a slight enlargement, the crop, in the center of the prothorax.

The oesophageal valve, a slight constriction marking the end of the fore-intestine and the beginning of the mid-intestine, is for the most part hidden by a wide circle of pipilliform crypts at the front end of the stomach. These crypts are longer than those found further back on the mid-intestine. (Plate I, Fig. 1.)

No salivary glands were found.

The Gross Structure of the Mid-Intestine.—The mid-intestine, or stomach, comprises the largest part of the alimentary tract, being 12 mm. in length. (Plate I, Fig. 1.) It extends from the oesophageal valve posteriorly as a straight tube for a distance of about 7 mm. Here it is 2 mm. in diameter and tapers for the rest of its length, being about ½ mm. in diameter for its posterior 5 mm. It is somewhat convoluted, bending upon itself and then extending cephalad. It is terminated by the pyloric valve and the malpighian tubules. There is a very interesting arrangement of the pipilliform crypts on the surface of the mid-intestine. Following the wide circle of crypts at the extreme front end of the stomach, there are six longitudinal rows for the anterior 7 mm. and four longitudinal rows for the remaining posterior 5 mm. In some other species of beetles it is noted that the crypts are scattered irregularly over the surface of the stomach and even in some they do not extend through the muscle layers to the surface.

In one of the specimens which was obtained in April and kept in the laboratory until June, the anterior end of the stomach was infested with fifteen Gregarines. All but one of the individuals examined in August from the July 30th collection were also infested. They were visible as white blotches through the wall of the stomach and quite well outlined against the dark fungal material which had been injested. Is it possible that they aid in the digestion of the woody fungus?

The Gross Structure of the Hind-Intestine.—The hind-intestine is composed of the pyloric valve, malpighian tubules, ileum, colon, and rectum (Plate I, Fig. 1). This portion of the alimentary canal is 10 mm. in length.

The pyloric valve shows as a constriction in the region of the tract where the rows of papillae abruptly stop. It is just posterior to the attachment of the malpighian tubules.

There are six malpighian tubules, arising from the cephalic end of the ileum and extending forward, dorsally, ventrally, and laterally into the thoracic region; here they bend backward and extend posteriorly to the colon, entering this just underneath the "peritoneal" covering and passing to the end of the colon, where they suddenly disappear. These tubules are visible through the "peritoneal" membrane and are very much convoluted, so that the posterior portion of the colon is almost covered by them. (Plate I, Fig. 1.)

The ileum is a narrow thin-walled tube, located between the pyloric valve and the colon. The anterior end is convoluted and approximately the same diameter as the posterior end of the stomach. In some specimens there was a constriction between the ileum and colon due to the position of the food material in the tract, but usually the ileum is found to continue gradually into the colon without any line marking its posterior limit. The colon is a short straight tube leading to the rectum.

The alimentary tract narrows near the anus to form the heavily chitinized rectum. It is 2 mm. in length.

HISTOLOGICAL STRUCTURE OF THE ALIMENTARY CANAL.

Fore-Intestine.—The layers of the oesophagus, as shown by Plate I, Fig. 2, from the lumen outward are as follows: (1) Intima of cuticula of chitin. (2) Epithelium of hypodermal cells. (3) Basement membrane. (4) Longitudinal muscle. (5) Circular muscle, and (6) "peritoneal" membrane.

The intima is secreted by the hypodermal cells and is a non-cellular, thin layer of chitinous material, homologous with the cuticula of the body wall. In this region it has numerous minute, very short, chitinous spines extending into the lumen.

A single layer of epithelial cells which is in wave-like folds throughout the fore-intestine lies next to the intima. The cells have very large nuclei and the basement membrane is evident, though not conspicuous.

The longitudinal muscles are in scattered groups outside the epithelial layer.

A continuous layer of circular muscle fibers surrounds the longitudinal muscles, and numerous nuclei are scattered throughout the fibers.

There are traces of connective tissue ("peritoneal" membrane) on the outermost part of the oesophagus.

The oesophageal valve (Plate I, Figs. 3 and 4) lies at the junction of the fore- and mid-intestine. In this region numerous long crypts extend out from the wall of the digestive tract making a complete circle around it. This valve consists of a rather large fold of the fore-gut

extending into the lumen of the mid-gut. The intima disappears at the region where the folds of the fore-gut proceed anteriorly. A single crypt opening is also noted at this region, reaching outward at the place where the reflected surface of the mid-intestine joins the fore-intestine. (The dense ring of crypts is slightly farther back on the front end of the stomach.) The epithelial cells of the valve folds are quite large and have distinct, large nuclei. It is here that the reversal in position of the longitudinal and circular muscles occurs. The longitudinal muscles lie internal to the circular muscles in the fore-intestine and external to this layer in the mid-intestine.

Mid-Intestine.—The oesophageal valve lies at the anterior end of the mid-intestine, while the pyloric valve is its posterior limit. This is commonly called the stomach and anteriorly it is about twice the diameter of the posterior portion. It is in this region of the alimentary tract that the papillae are arranged in rows, six anterior and four posterior. See Plate I, Figs. 5 and 6, and Plate II, Fig. 7. Large globules of liquid are present in the lumen of the stomach, indicating merocrine secretion (Plate II, Fig. 8).

Histologically the layers of the anterior and posterior stomach are similar. From the lumen outward are noted the epithelial cells. The layer is one cell in thickness. The striated border resembling cilia is visible on some of these epithelial cells, although those cells which have globules of secreted material at their ends, show no such border. The basement membrane, at the base of the epithelial cells, is not very distinct. A rather thick circular muscle layer is next, and to the outside of this are scattered bundles of longitudinal muscle fibers. A thin "peritoneal" membrane is seen at places covering the longitudinal muscle cells. The nuclei in both the longitudinal and circular muscle layers are quite distinct. There is no intima in this region covering the epithelial cells. Two types of secretion are indicated here, merocrine and holocrine. Merocrine secretion is when the product is secreted by the cells, the latter not being destroyed, while holocrine secretion is when the entire substance of the cells is given up as a secretory product. It appears that holocrine secretion occurs in the long crypts which extend from the surface of the mid-intestine. (Plate I, Fig. 6, Plate II, Fig. 7.) Merocrine secretion takes place at first in the flat inner wall of the stomach, as the globules of secreted material in the lumen show. Later holocrine secretion probably occurs in the epithelial cells of the stomach wall for we find that the nuclei of the cells are very irregular in arrangement, the younger merocrine secreting cells having their nuclei at the base of the cells and the older (holocrine?) secreting cells have the nuclei almost at the end of the cell toward the lumen. (Plate II, Fig. 8.)

The crypts are rounded on the free ends or tips where they contain many nuclei. (Plate I, Fig. 6.) The tip is a nidus.

Hind-Intestine.—The junction of the mid- and hind-intestine is indicated externally by six malpighian tubules which are almost at the level of the last crypts. The tubules come from the hind-intestine and the walls are composed of irregularly shaped cells with large ovate nuclei. There is a lining of intima next to the lumen of the tubules. A delicate "peritoneal" membrane covers the tubules.

The pyloric valve lies just posterior to the attachment of the malpighian tubules. The epithelial cells here are thrown into folds and covered on the lumen side by a lining of intima. There is a thick layer of circular muscle fibers extending the length of the valve. On each side of the circular muscles are scattered groups of longitudinal muscle cells. The exterior layer of longitudinal muscles is almost absent in the region of the pyloric valve. The valvular condition is due to the very thick circular muscle layer at the region where the valve makes a bend. (Plate II, Figs. 9 and 10.)

The hind-intestine begins at the end of the pyloric valve and continues to the anus. The general arrangement of the cell layers is practically the same in the three regions of the hind-intestine, there being an inner lining of intima of cuticula, an epithelial layer, a circular muscle layer, and a longitudinal muscle layer. The intima and epithelial cells are thrown into many folds. (Plate II, Fig. 11.) The cells of the epithelial layer are large, rather cuboidal in shape, and possess very large nuclei located usually at the base of the cells. The circular muscle layer forms a continuous layer, while the longitudinal layer is composed of scattered groups of cells. These muscles are all striated.

A section of the colon (Plate II, Fig. 12) shows the continuous circular muscle layer dipping to touch the intima between the epithelial cells which are arranged in six groups. The longitudinal muscles are also in groups lying between the malpighian tubules. (Plate II, Fig. 13.)

The muscle wall of the rectum is very heavy and is made up largely of circular muscle tissue with a few groups of longitudinal muscle cells scattered near the surface. (Plate II, Fig. 14.) The epithelial cells are smaller than those in the more anterior part of the hind-intestine and they, with the intima, are folded into six distinct groups, known as the rectal pads.

The intima is much thicker here than in the colon. There is a "peritoneal" membrane in this region similar to that in other parts of the tract.

A pair of enlarged anal glands lie in the posterior abdominal region in front of and above the rectum. They are somewhat oval in shape, having a mushroom-shaped cap of secreting cells. Posterior to this cap is the thin-walled reservoir. The reservoirs of the right and left glands unite posteriorly and widen to form the excretory canal. The glands and reservoirs are yellowish in color, due to secreted material in them. According to Bordas (1899) the anal glands function as organs of defense; the yellow fluid secreted by them becomes volatile in contact with air and is of a pungent and acid nature. No histological study was made of these structures, but the manner of attachment of the cap to the reservoir and the connection of the gland to the outside are points quite worthy of further investigation.

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ABBREVIATIONS FOR PLATES.

AN. GL. . . Anal gland.
B. M. . . . . . Basement membrane.
C. M. . . . . . Circular muscle.
CR. . . . . . . Crypt.
EPI. . . . . . Epithelium.
IL. . . . . Ileum.
IN. . . . . Intima.
L. M. . . . . Longitudinal muscle.
LU. . . . . . . Lumen.
MT. . . . . . . Malpighian tubules.
N. . . . . Nucleus.
NI. . . . . Nidus.
OES. . . . . Oesophagus.
OES. V. . . Oesophageal valve.
PTL. M. . . Peritoneal membrane.
P. V. . . . . . Pyloric valve.
RE. . . . . . . Rectum.
R. P. . . . . Rectal pad.
ST. . . . . Stomach.
VAL. . . . . . Valve.

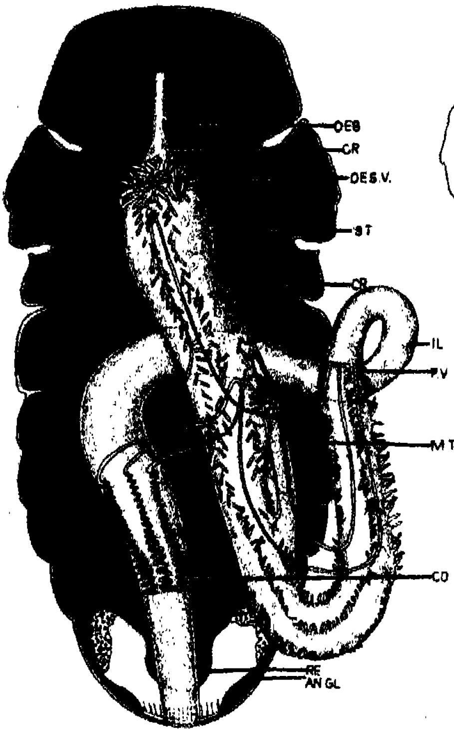

FIG I

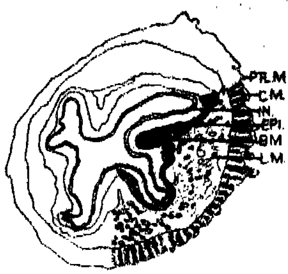

FIG 2

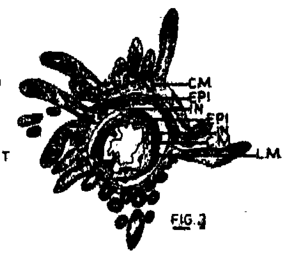

FIG. 3

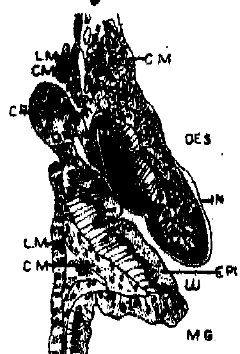

FIG 4

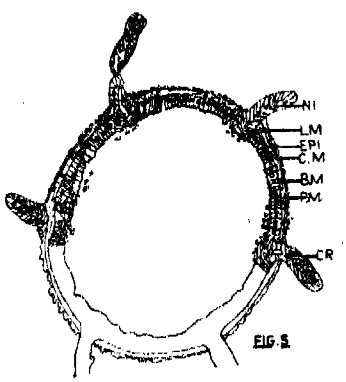

FIG. 5

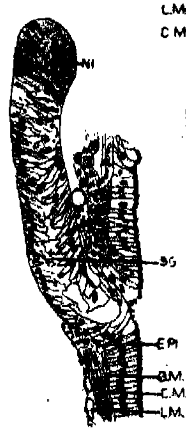

FIG 6

Fig. 1. Dorsal view showing gross dissection of the Alimentary Canal.
Fig. 2. Cross-section through Oesophagus.
Fig. 3. Cross-section through Oesophageal Valve.
Fig. 4. Longitudinal section through Oesophageal Valve.
Fig. 5. Cross-section through anterior mid-gut showing six Crypts.
Fig. 6. Cross-section through anterior mid-gut and a longitudinal section of a crypt (enlarged).

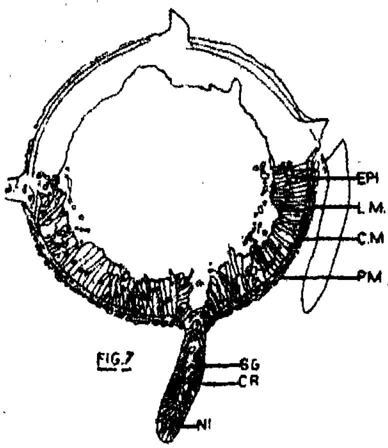

FIG. 7

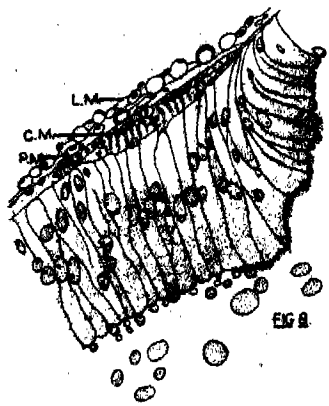

FIG. 8

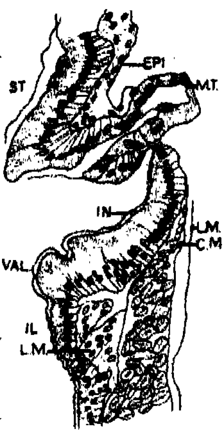

FIG. 9

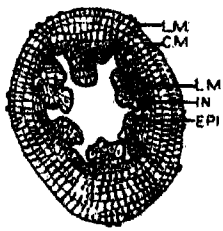

FIG. 10

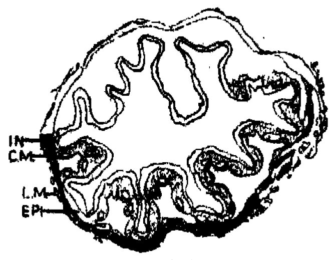

FIG. 11

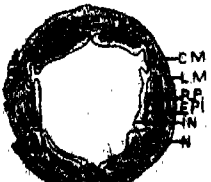

FIG. 14

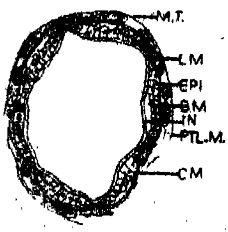

FIG. 12

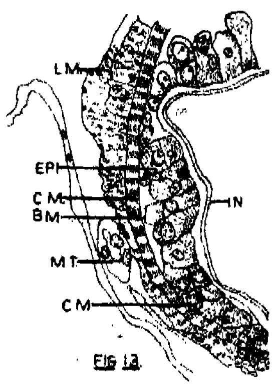

FIG. 13

Fig. 7. Cross-section through posterior mid-gut showing four crypts.
Fig. 8. Enlarged drawing of portion of Fig. 7.
Fig. 9. Longitudinal section showing the pyloric valve.
Fig. 10. Cross-section through the pyloric valve.
Fig. 11. Cross-section through the ileum.
Fig. 12. Cross-section through the colon.
Fig. 13. Detailed drawing of portion of Fig. 12.
Fig. 14. Cross-section through rectum.

ADDITIONS TO THE REVISED CATALOG OF OHIO VASCULAR PLANTS. I.*

JOHN H. SCHAFFNER.

The publication of a new catalog of Ohio vascular plants† in the spring of 1932 has apparently stimulated collectors to more intensive activity and in consequence a very large number of specimens have been received for the State Herbarium. Only the most important additions are given in the list below and of these 41 are entirely new to the state catalog. Several records have also been obtained of species in the published list which were not represented by any specimen in the herbarium. Typographical errors appear in two distribution records in the new catalog and should be corrected as follows: 2160. *Aster novae-angliae* L., read—General and abundant; 1132. *Geum strictum* Ait., read—Northeastern part of state; etc., instead of Northwestern. New records are inserted in the proper places by means of decimal numbers.

SCHIZAEACEAE. Climbing-fern Family.

10.1. *Lygodium palmatum* (Bern.) Sw. Climbing-fern. Pine Forest, Carbondale, Athens Co. Elizabeth E. Inmann. Same locality, Floyd B. Chapman.

12. *Polypodium polypodioides* (L.) Hitch. Gray Polypody. Rocky Fork, Highland Co. Leslie L. Pontius and Floyd Bartley.

47. *Pteretis nodulosa* (Mx.) Nieuwl. American Ostrich-fern. Common along roadside, Windsor Twp., Ashtabula Co. L. E. Hicks.

60. *Equisetum silvaticum* L. Wood Horsetail. Nelson Twp., N. E. Portage Co. R. J. Campbell.

63. *Lycopodium porophilum* Lloyd & Und. Rock Club-moss. Phelps Run, Ashtabula Co. L. E. Hicks.

64. *Lycopodium inundatum* L. Bog Club-moss. Bottom of abandoned stone quarry. Braceville Twp., Trumbull Co. Almon N. Rood.

66.1. *Lycopodium tristachyum* Pursh. Slender Trailing Club-moss. On edge of very dry bank along Conneaut River near Conneaut, Ashtabula Co. L. E. Hicks.

68. *Selaginella rupestris* (L.) Spring. Rock Selaginella. Newell Ledge, Nelson Twp., Portage Co. Almon N. Rood, R. J. Webb, and E. W. Vickers.

BUTOMACEAE. Flowering-rush Family.

87.1. *Butomus umbellatus* L. Flowering-rush. Little Cedar Point, Jerusalem Twp., Lucas Co. From Europe. Louis W. Campbell.

93. *Potamogeton pulcher* Tuck. Spotted Pondweed. South of Cardinal Lake, Ashtabula Co. L. E. Hicks.

101. *Potamogeton perfoliatus* L. Clasping-leaf Pondweed. On beach at Sweden and East Ashtabula, Ashtabula Co. L. E. Hicks.

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*Papers from the Department of Botany, The Ohio State University, No. 319.

†SCHAFFNER, JOHN H. Revised Catalog of Ohio Vascular Plants. Ohio Biol. Surv. *5* (2): 87–215. 1932. (Bull. No. 25).

106. *Potamogeton vaseyi* Robb. Vasey's Pondweed. Small pond along Conneaut River near Farnham, Ashtabula Co. L. E. Hicks.
108. *Potamogeton dimorphus* Raf. Spiral Pondweed. In pond at McArthur, Vinton Co. L. E. Hicks.
112.1. *Naias quadalulpensis* (Spreng.) Mor. Guadaloupe Naias. Abundant in streams in Williamsfield Twp., Ashtabula Co. L. E. Hicks.
118. *Castalia tuberosa* (Paine) Greene. Tuberous Water-lily. Near East Tiberly, Summit Co., mouth of Conneaut River and pond along Ashtabula River., Ashtabula Co. L. E. Hicks.
122. *Sparganium androcladum* (Engelm.) Morong. Branching Bur-reed. Rock Run, Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.
138.1. *Wolffia papulifera* Thomp. Pointed Wolffia. In a small pool, Salt Creek, Liberty Twp., near Coal Twp., Jackson Co. Robert B. Gordon.
142. *Scirpus sylvaticus* L. Wood Bulrush. Swampy ground. Richland Co. E. Wilkinson.
145.1. *Scirpus heterochaetus* Chase. Pale Great Bulrush. In a swamp. Mantua Twp., Portage Co. Almon N. Rood.
149. *Scirpus debilis* Pursh. Weak Clubrush. Painesville, Lake Co. Wm. C. Werner.
152. *Eriophorum viridicarinatum* (Engelm.) Fern. Thin-leaf Cotton-sedge. Painesville, Lake Co. Wm. C. Werner.
160. *Eleocharis intermedia* (Muhl.) Schultes. Matted Spike-rush. Columbus, Franklin Co. Wm. C. Werner.
172. *Cyperus speciosus* Vahl. Michaux's Cyperus. Painesville, Lake Co. Wm. C. Werner.
187. *Mariscus mariscoides* (Muhl.) Ktz. Twig-rush. Cedar Swamp, Champaign Co. Wm. C. Werner. Mantua Twp., Portage Co., Almon N. Rood.
189. *Scleria triglomerata* Mx. Tall Nut-rush. Nettle Lake, Williams Co. Floyd Bartley and Leslie L. Pontius.
200. *Carex plana* Mack. Painesville, Lake Co. Wm. C. Werner.
212. *Carex prarea* Dew. Prairie Sedge. Painesville, Lake Co. Wm. C. Werner.
216. *Carex crus-corvi* Shuttlw. Raven-foot Sedge. Wood Co. Albert Neifer and Wm. C. Werner; Scioto Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.
222. *Carex interior* Bail. Inland Sedge. Painesville, Lake Co. Wm. C. Werner.
223. *Carex sterilis* Willd. Barren Sedge. Cedar Swamp, Champaign Co. Wm. C. Werner.
230.1. *Carex projecta* Mack. Necklace Sedge. Painesville, Lake Co. Dr. H. C. Beardslee (1879). Sent in by Mr. Wm. C. Werner.
242. *Carex foena* Willd. Hay Sedge. Painesville, Lake Co. Wm. C. Werner.
249. *Carex gynandra* Schw. Nodding Sedge. Buchtel, Athens Co. Len. Stephenson.
303. *Carex atherodes* Spreng. Awned Sedge. "Onion Island," Buckeye Lake, Fairfield Co. Edward S. Thomas.
304.1. *Carex viridula* Mx. Green Sedge. (*C. oederi pumila* (C. & G.) Fern.) Cedar Swamp, Champaign Co. Wm. C. Werner.
305. *Carex cryptolepis* Mack. Small Yellow Sedge. Mantua Twp., Portage Co. Almon N. Rood and R. J. Webb.
306. *Carex flava* L. Yellow Sedge. Cedar Swamp, Champaign Co. Wm. C. Werner. "Urbana Bog," Champaign Co. E. Lucy Braun.
333.1. *Bromus altissimus* Pursh. Tall Brome-grass. Braceville Twp., Trumbull Co. Almon N. Rood. Painesville, Lake Co. Wm. C. Werner.
334.1. *Bromus asper* Murr. Rough Brome-grass. Daleyville, Pike Co. Leslie L. Pontius and Floyd Bartley.
410.1. *Alopecurus myosuroides* Huds. Slender Foxtail. Accidental. A number of clumps on Ohio State University Farm. Columbus, Franklin Co. C. J. Willard.
413. *Alopecurus aristatulus* Mx. Short-awned Foxtail. Near Columbus, Franklin Co., Wm. C. Werner; Cedar Swamp, Champaign Co., John H. Schaffner.

430. *Aristida purpurascens* Poir. Purplish Triple-awn-grass. Liberty Twp., Highland Co. Katie M. Roads.
508. *Paspalum setaceum* Mx. Slender Paspalum. Liberty Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.
508.1. *Paspalum pubescens* Muhl. Pubescent Paspalum. Plentiful in fields near Painesville, Lake Co. Identified by A. S. Hitchcock. Wm. C. Werner.
517. *Miscanthus sinensis* Anderss. Chinese Plume-grass. A large well established patch along bank of railway. Brush Creek Twp., Scioto Co. Katie M. Roads; Longstreth, Hocking Co. Len. Stephenson.
547. *Aletris farinosa* L. Colic-root. Colerain Twp., Ross Co.; Jackson Twp., Vinton Co.; near Nettle Lake, Williams Co. Leslie L. Pontius and Floyd Bartley.
554. *Triantha glutinosa* (Mx.) Baker. Glutinous Triantha. Paxton Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.
594. *Juncus balticus* Willd. Baltic Rush. Bay Point, Ottawa Co., and Conneaut, Ashtabula Co. L. E. Hicks.
599.1. *Juncus greenei* Oakes and Tuck. Green's Rush. Abundant in low, wet swale. Phalanx, Trumbull Co. Almon N. Rood.
614. *Xyris flexuosa* Muhl. Slender Yellow-eyed-grass. Wood Co. Albert Kneifer. Sent by Wm. C. Werner.
647. *Blephariglottis blephariglottis* (Willd.) Rydb. White Fringed-orchis. East Andover Twp., Ashtabula Co. L. E. Hicks.
656. *Ibidium strictum* (Rydb.) House. Hooded Lady's-tresses. Goodhope Twp., Hocking Co. Floyd B. Chapman.
659. *Ibidium beckii* (Lindl.) House. Little Lady's-tresses. Farnham, Ashtabula Co. L. E. Hicks. Buchtel, Athens Co. Len. Stephenson.
660.1. *Peramium tesselatum* (Lodd.) Heller. Loddiges' Rattlesnake-plantain. (*Epipactis tesselata* (Lodd.) A. A. Eat.). Along Phelps Run, Ashtabula Co. L. E. Hicks.
686. *Ranunculus bulbosus* L. Bulbous Buttercup. Ashtabula, Ashtabula Co. L. E. Hicks.
688. *Ranunculus repens* L. Creeping Buttercup. New Castle Twp., Coshocton Co. Frank B. Selby.
688a. *Ranunculus repens pleniflorus* Fern. Double-flowered Creeping Buttercup. Geneva, Ashtabula Co. L. E. Hicks.
694. *Ranunculus pusillus* Poir. Dwarf Crowfoot. East Monroe Twp., Ashtabula Co. L. E. Hicks.
701. *Nigella damascena* L. Love-in-a-mist. In a pasture lot. Hillsboro, Highland Co. Katie M. Roads.
705.1. *Delphinium cultorum* Voss. Candle Larkspur. Persistent in Conneaut, Ashtabula Co. L. E. Hicks.
707. *Delphinium exaltatum* Ait. Fall Larkspur. Persistent at Ashtabula, Ashtabula Co. L. E. Hicks.
721. *Actaea rubra* (Ait.) Willd. Red Baneberry. Springfield and Jerusalem Twps., Lucas Co. Louis W. Campbell; Wayne Twp., Ashtabula Co. L. E. Hicks. Clifton Gorge, Greene Co. Arthur R. Harper.
760. *Fumaria officinalis* L. Common Fumitory. Kingsville, Ashtabula Co. L. E. Hicks.
768. *Lunaria annua* L. Honesty. Green Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.
791.1. *Sophia sophia* (L.) Britt. Herb-Sophia. In a pasture lot. Hillsboro, Highland Co. Katie M. Roads.
798. *Norta irio* (L.) Britt. Longleaf Hedge-mustard. Along railroad embankment, Marion Co. F. B. Chapman.
837. *Brassica napus* L. Rape. Hillsboro, Highland Co. Katie M. Roads.
850. *Geranium columbinum* L. Long-stalked Crane's-bill. Jackson Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.
853. *Geranium pusillum* L. Small-flowered Crane's-bill. Green Twp., Ross Co. Leslie L. Pontius and Floyd Bartley.
855. *Erodium cicutarium* (L.) L'Her. Stork's-bill. In a field of crimson clover, Hillsboro, Highland Co. Katie M. Roads.
862. *Oxalis acetosella* L. White Wood-sorrel. Pymatuning Swamp, Ashtabula Co. L. E. Hicks.

864. *Linum perenne* L. Perennial Flax. Persistent along river at Conneaut, Ashtabula Co. L. E. Hicks.

867. *Linum striatum* Walt. Ridged Flax. Jackson Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley; Andover, Ashtabula Co. L. E. Hicks.

876. *Zanthoxylum americanum* Mill. Prickly-ash. Windsor Twp., Ashtabula Co. L. E. Hicks.

879. *Polygala pauciflora* Willd. Fringed Milkwort. Margin of white pine woods, Farnham, Ashtabula Co. L. E. Hicks.

887. *Phyllanthus carolinensis* Walt. Carolina Phyllanthus. Liberty Twp., Ross Co. Leslie L. Pontius and Floyd Bartley.

917.1. *Malva verticillata* L. Whorled Mallow. In a pasture lot in Hillsboro, Highland Co. Katie M. Roads.

947. *Hypericum canadense* L. Canadian St. John's-wort. Conneaut, Ashtabula Co. L. E. Hicks.

950.1. *Triadenum longifolium* Small. Long-leaf Marsh St. John's-wort. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

953. *Crocanthemum canadense* (L.) Britt. Canada Frostweed. Abundant on river banks in East Conneaut, Ashtabula Co. L. E. Hicks.

956. *Lechea racemulosa* Lam. Oblong-fruited Pinweed. One mile south of Portage, Wood Co., and near Conneaut, Ashtabula Co. L. E. Hicks.

960. *Lechea leggettii* Britt. & Holl. Leggett's Pinweed. Portage, Wood Co., Liberty Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

961. *Lechea intermedia* Legg. Large-podded Pinweed. Dry upland pasture. Hanover Twp., Ashland Co. R. B. Gordon.

972. *Viola tricolor* L. Garden Pansy. Escaped along river at Conneaut, Ashtabula Co. L. E. Hicks.

979. *Viola affinis* LeC. Thinleaf Blue Violet. Liberty Twp., Ross Co. Leslie L. Pontius and Floyd Bartley.

998. *Moehringia lateriflora* (L.) Fenzl. Bluntleaf Moehringia. Conneaut, Ashtabula Co. L. E. Hicks.

1000. *Alsine aquatica* (L.) Britt. Water Chickweed. Painesville, Lake Co. Wm. C. Werner. In small pond near Saybrook, Ashtabula Co. L. E. Hicks.

1002. *Alsine pubera* (Mx.) Britt. Great Chickweed. Near Geneva, Ashtabula Co. L. E. Hicks.

1006. *Cerastium viscosum* L. Mouse-ear Chickweed. Liberty Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

1011. *Spergula arvensis* L. Corn Spurry. Four miles east of Barnesville, Belmont Co. Emma E. Laughlin and Edward Ransom. Growing along fence-row near Saybrook, Ashtabula Co. L. E. Hicks.

1028. *Silene wherryi* Small. Wherry's Catchfly. Bourneville, Ross Co. and in Adams Co. near Scioto Co. line. Katie M. Roads.

1037. *Dianthus prolifer* L. Proliferous Pink. Dry fields, Cleveland, Cuyahoga Co. L. D. Stair. Lost specimen recovered.

1039. *Limnia perfoliata* (Donn) Haw. Spanish-lettuce. Painesville, Lake Co. Wm. C. Werner.

1049. *Scleranthus annuus* L. Knawel. Near Beallsville, Monroe Co. Harry Briggs.

1063. *Chenopodium vulvaria* L. Fetid Goosefoot. Circleville, Pickaway Co. Leslie L. Pontius and Floyd Bartley; Napoleon, Henry Co. E. H. Bond.

1104.1. *Tiniaria cilinodis* (Mx.) Small. Fringed Black Bindweed. Conneaut River west of Farnham, Ashtabula Co. L. E. Hicks.

1132. *Geum strictum* Ait. Yellow avens. Nettle Lake, Williams Co. Leslie L. Pontius and Floyd Bartley.

1144.1. *Duchesnea indica* (Andr.) Focke. Indian Strawberry. Introduced from Eurasia. Growing on shaded banks near the lake shore east of Ashtabula, Ashtabula Co. L. E. Hicks; Circleville Twp., Pickaway Co. Leslie L. Pontius and Floyd Bartley.

1149. *Rubus phoenicolasius* Max. Wineberry. Common in a ravine along Lake Erie, near Amboy, Ashtabula Co. L. E. Hicks.

1149.1. *Rubus idaeus* L. Red Raspberry. From Europe. Escaped near Amboy, Ashtabula Co. L. E. Hicks.

1158. *Rubus laciniatus* Willd. Cutleaf Blackberry. Near mouth of Conneaut River, Ashtabula Co. L. E. Hicks.

1164.1. *Spiraea latifolia* (Ait.) Borkh. American Meadow-sweet. Near Painesville, Lake Co. Wm. C. Werner.

1167. *Spiraea prunifolia* Sieb. & Zucc. Bridal-wreath (Spiraea). Escaped near Colebrook, Ashtabula Co. L. E. Hicks.

1170.1. *Rosa wichuraiana* Crep. White Dorothy Perkins variety of this. Long persistent and spreading about the site of a former dwelling. South Windsor Twp., Ashtabula Co. Original from Japan. L. E. Hicks.

1175.1. *Rosa cinnamomea* L. Cinnamon Rose. A common escape. Windsor Twp., Ashtabula Co. L. E. Hicks.

1176. *Rosa rugosa* Thunb. Japanese Rose. Escaped on high beach dunes at Geneva-on-the-Lake, Ashtabula Co. L. E. Hicks.

1182. *Agrimonia striata* L. Striate Agrimony. East Monroe Twp., Ashtabula Co. L. E. Hicks.

1189. *Prunus pennsylvanica* L. f. Red Cherry. East Monroe Twp., Ashtabula Co. L. E. Hicks.

1214. *Crataegus brainerdi* Sarg. Brainerd's Hawthorn. Farmington Twp., Trumbull Co. Almon N. Rood.

1254. *Trifolium reflexum* L. Buffalo Clover. Ashtabula Twp., Ashtabula Co. L. E. Hicks.

1264.1. *Wisteria frutescens* (L.) Poir. American Wisteria. (*Kraunhia frutescens* (L.) Greene.) Escaped and long persistent near former dwelling site near Phelps Run, Ashtabula Co. L. E. Hicks.

1285. *Meibomia arenicola* Vail. Sand Tick-trefoil. Perkins, Erie Co. E. L. Moseley.

1321. *Galacta volubilis* (L.) Britt. Downy Milk-pea. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

1322. *Phaseolus polystachyus* (L.) B. S. P. Wild Bean. Brush Creek Twp., Highland Co.; Colerain Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

1352. *Rhamnus caroliniana* Walt. Carolina Buckthorn. Adams Co., two miles from Brown Co. line and about fifteen miles north of the Ohio River. Mrs. W. L. Hughes.

1353. *Rhamnus frangula* L. Black Buckthorn. Bucyrus, Crawford Co. Volunteer or accidental. J. H. Ulmer.

1359.1. *Vitis labruscana* Bail. Labruscan Vineyard Grape. A white berried cultivated variety frequently escaped and persistent at Hartsgrove, Ashtabula Co. L. E. Hicks. Seedlings from Concord Crape escaped and persistent in Columbus, Franklin Co. John H. Schaffner.

1436.1. *Corylus rostrata* Ait. Beaked Hazelnut. Along Grand River near Harpersfield, Ashtabula Co. L. E. Hicks.

1472a. *Salix interior wheeleri* Rowlee. Ashtabula Beach, Ashtabula Co. L. E. Hicks.

1490.1. *Ribes glandulosum* Grauer. Fetid Current. East Monroe Twp., Ashtabula Co. L. E. Hicks.

1501.1. *Epilobium hirsutum* L. Great Hairy Willow-herb. Swamp near Conneaut, Ashtabula Co. L. E. Hicks.

1509. *Kneiffia pratensis* Small. Meadow Sundrops. Near Geneva-on-the-Lake, Ashtabula Co. L. E. Hicks.

1513. *Kneiffia longipedicellata* Small. Long-pedicelled Sundrops. Liberty Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

1523. *Myriophyllum heterophyllum* Mx. Variant-leaf Water-milfoil. Marsh at Geneva-on-the-Lake, Ashtabula Co. L. E. Hicks.

1529. *Citrullus citrullus* (L.) Karst. Watermelon. Spontaneous along East Conneaut Road, Ashtabula Co. L. E. Hicks.

1538. *Ledum groenlandicum* Oedr. Labrador-tea. East Andover Twp., Ashtabula Co. L. E. Hicks.

1539.1. *Azalea canescens* Mx. Hoary Azalea. "In a muck area now destroyed," near Painesville, Lake Co. Wm. C. Werner; Phelps Creek, Ashtabula Co. L. E. Hicks.

1543. *Epigaea repens* L. Trailing Arbutus. Laurel Hill, near White Cottage, Muskingum Co. Jeanette A. Reed.

1563. *Vaccinium canadense* Kahn. Canada Blueberry. East Andover Twp., Ashtabula Co. L. E. Hicks.

1564. *Chiogenes hispidula* (L.) T. & G. Creeping Snowberry. East Andover Twp., Ashtabula Co. L. E. Hicks.

1570.1. *Polemonium coeruleum* L. Jacobs-ladder. Long-persistent about the site of a former dwelling in Windsor Twp., Ashtabula Co. L. E. Hicks.

1577. *Phlox ovata* L. Mountain Phlox. Highland Co. Reported by Edgar T. Wherry. Bartonia 13: 27. 1931.

1577a. *Phlox ovata carolina* (L.) Wherry. Near Cincinnati, Hamilton Co. (Lea Herbarium, Acad. Nat. Sci. Philadelphia), collected in 1839. Adams Co. (E. Lucy Braun Herb.)

1650. *Asclepias variegata* L. White Milkweed. Georgesville, Franklin Co. Wm. C. Werner.

1661. *Datura metel* L. Entire-leaf Jinson-weed. Napoleon, Henry Co. E. H. Bond.

1710. *Aureolaria laevigata* (Raf.) Raf. Entire-leaf False Foxglove. Below Harpersfield, Ashtabula Co. L. E. Hicks.

1737. *Antirrhinum majus* L. Great Snapdragon. Escaped near Geneva, Ashtabula Co. L. E. Hicks.

1746. *Paulownia tomentosa* (Thunb.) Baill. Paulownia. Near Buena Vista in both Adams and Scioto Cos. L. E. Hicks.

1759. *Stomoisia cornuta* (Mx.) Raf. Horned Bladderwort. Cedar Swamp, Champaign Co., near Bowlusville. Wm. C. Werner.

1769.1. *Cynoglossum boreale* Fern. Northern Wild Confrey. East Monroe Twp., Ashtabula Co. L. E. Hicks.

1774. *Lithospermum carolinense* (Walt.) Mack. Hairy Puccoon. East Conneaut Beach, Ashtabula Co. L. E. Hicks.

1780. *Myosotis micrantha* Pall. Small-flowered Forget-me-not. Near Painesville, Lake Co. Wm. C. Werner.

1781.1. *Anchusa officinalis* L. Alkanet. Introduced near Painesville, Lake Co. W. C. Werner.

1782.1. *Symphytum asperimum* Donn. Rough Comfrey. Introduced near Painesville, Lake Co. Wm. C. Werner.

1785. *Lycopsis arvensis* L. Small Bugloss. Escaped near Austinburg, Ashtabula Co. L. E. Hicks; Painesville, Lake Co. Wm. C. Werner.

1792. *Verbena hybrida* Voss. Common Garden Verbena. Escaped near Saybrook, Ashtabula Co. L. E. Hicks.

1796.1. *Ajuga reptans* L. Creeping Bugleweed. Spontaneous at Painesville, Lake Co. Wm. C. Werner.

1805. *Scutellaria pilosa* L. Hairy Skullcap. Benton Twp., Hocking Co. Floyd Bartley and Leslie L. Pontius.

1814. *Mentha citrata* Ehrh. Bergamot Mint. Buchtel, Athens Co. Len. Stephenson.

1831. *Koellia pycnanthemoides* (Leav.) Ktz. Southern Mountain-mint. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

1841. *Hedeoma hispida* Pursh. Rough Pennyroyal. Oak Openings, Lucas Co. Floyd Bartley and Leslie L. Pontius.

1872. *Salvia pitcheri* Torr. Wild Blue Sage. Persistent after cultivation. Hillsboro, Highland Co. Katie M. Roads.

1892. *Hydrocotyle umbellata* L. Umbellate Marsh-pennywort. Conneaut River, Ashtabula Co. L. E. Hicks.

1942. *Cynoxylon canadense* (L.) Dwarf Dogwood. Near Streetsboro, Portage Co. Leslie L. Pontius and Floyd Bartley; Painesville, Lake Co. Wm. C. Werner.

1954.1. *Diodia virginiana* L. Virginia Buttonweed. Along the Ohio River shore, Adams Co. Conrad Roth.

1955. *Galium verum* L. Yellow Bedstraw. Hillsboro, Highland Co. Katie M. Roads.

1956. *Galium boreale* L. Northern Bedstraw. E. Monroe Twp., Ashtabula Co. L. E. Hicks.

1985. *Triosteum aurantiacum* Bickn. Scarlet-fruited Horse-gentian. Buchtel, Athens Co. Len. Stephenson.

1991.1. *Lonicera coerulea* L. Blue Fly Honeysuckle. Pymatuning Swamp, Ashtabula Co. L. E. Hicks.

1994. *Lonicera sempervirens* L. Trumpet Honeysuckle. South of Oak Hill, Jackson Co. Floyd Bartley and Leslie L. Pontius.

2027.1. *Ambrosia bidentata* Mx. Lanceleaf Ragweed. Dean Forest, Lawrence Co. From the West. Floyd Bartley and Leslie L. Pontius.

2039a. *Rudbeckia laciniata hortensia* Bail. Golden-glow. Escaped in East Pierpoint Twp., Ashtabula Co. L. E. Hicks.

2050. *Helianthus instabilis* Wats. Unstable Sunflower. Dorset, Ashtabula Co. L. E. Hicks.

2081. *Megalodonta beckii* (Torr.) Greene. Water-marigold. Conneaut Harbor, Ashtabula Co. L. E. Hicks.

2082. *Coreopsis lanceolata* L. Lanceleaf Tickseed. Hillsboro, Highland Co. Katie M. Roads; West Alexandria, Preble Co. L. E. Hicks.

2095. *Silphium terebinthinaceum pinnatifidum* (Ell.) Gr. Wayne Twp., Pickaway Co. Leslie L. Pontius and Floyd Bartley.

2101. *Tagetes erecta* L. Large Marigold. Escaped at Conneaut, Ashtabula Co. L. E. Hicks.

2117. *Chrysopsis gramnifolia* (Mx.) Ell. Grass-leaf Golden-aster. Lynx Prairie, Adams Co. L. E. Hicks.

2136. *Solidago neglecta* T. & G. Swamp Goldenrod. Green Twp., Ross Co. Leslie L. Pontius and Floyd Bartley.

2146. *Sericocarpus linifolius* (L.) B. S. P. Narrowleaf Whitetop Aster. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

2156. *Aster drummondii* Lindl. Drummond's Aster. Georgesville, Franklin Co. Wm. C. Werner.

2157. *Aster undulatus* L. Wavy-leaf Aster. Buffalo Beat, near Buchtel, Athens Co. L. E. Hicks and E. S. Thomas.

2161. *Aster patens* Ait. Late Purple Aster. Georgesville, Franklin Co. Wm. C. Werner.

2170. *Aster multiflorus* Ait. Dense-flowered Aster. Painesville, Lake Co. Wm. C. Werner.

2172. *Aster salicifolius* Lam. Willow Aster. Painesville, Lake Co.; Columbus, Franklin Co. Wm. C. Werner.

.1. *Aster acumniatus* Mx. Whorled Aster. East Monroe Twp., Ashtabula Co. L. E. Hicks.

2177.1. *Aster subulatus* Mx. Annual Saltmarsh Aster. On sandy, saline soil near oil wells, old lake beach, five miles south of Bowling Green, Wood Co. E. L. Moseley.

2218. *Matricaria chamomilla* L. German Chamomile. Painesville, Lake Co. and Hanging Rock, Lawrence Co. Wm. C. Werner.

2229.1. *Senecio sylvaticus* L. Wood Groundsel. From Europe. Painesville, Lake Co. Wm. C. Werner.

2250. *Cirsium odoratum* (Muhl.) Britt. Fragrant Thistle. On sand ridge south east of Conneaut, Ashtabula Co. L. E. Hicks.

2255. *Centaurea jacea* L. Brown Star-thistle. N. E. corner Bazetta Twp., Trumbull Co. R. J. Campbell. On bank of Penn Line Bog, Ashtabula Co. L. E. Hicks; Columbus, Franklin Co. and Mentor, Lake Co. Wm. C. Werner.

2258. *Centaurea vochinensis* Bernh. Tyrol Star-thistle. South of Ashtabula, Ashtabula Co. L. E. Hicks.

2270. *Apargia autumnalis* (L.) Hoffm. Fall Hawkbit. Painesville, Lake Co. Wm. C. Werner.

2297. *Sonchus uliginosus* Bieb. Glandless Field Sow-thistle. South of Kenton, Hardin Co. Leslie L. Pontius and Floyd Bartley.

The Background of Science.

In an early chapter of this stimulating and fundamental discussion of physical science Sir James Jeans says, "It is frequently more difficult to frame a sensible question than to obtain an answer to a nonsensical one." The book is largely given over to the framing of sensible basic questions to be asked of nature, and to nature's replies to these questions. The discussion is necessarily technical, but it is made extremely readable by the wealth of clear analogies presented. The book is the last word on the basic framework of science.—L. H. S.

The New Background of Science, by Sir James Jeans. viii + 301 pp. New York, the MacMillan Co., 1933.

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FOREWORD.

The Symposium on Metabolism, which is presented here, has as its basis a course of lectures that was given before the Ohio State Chapter of the Society of the Sigma Xi during the academic year 1932–33. At that time the personnel of the Executive Committee, which is charged with determining the policies of the chapter, was as follows:

Professor J. F. Lyman, *President.*
Professor F. C. Blake, *Councilor.*
Professor E. M. Spieker, *Vice-President.*
Professor F. A. Hitchcock, *Secretary.*

It was the unanimous opinion of this committee that the program for the year would be both more valuable and more interesting if it were arranged so that various aspects of the same central topic furnished the subjects for the meetings held throughout the year. After careful consideration the subject of Metabolism was selected as the central topic. While it was recognized that a course of lectures on this topic would be of interest primarily to the biologists of the Chapter, it was believed that the subject involved sufficient applications of physics and chemistry to make the course worth while to the non-biological scientist.

The authors of the various papers have all made valuable contributions to our knowledge of metabolism, and the major portion of the material given in each paper is obtained from the original researches of the author. The material is presented in such a way as to make it comprehensible to the intelligent layman.

The committee wishes to express its appreciation to the authors of the various papers, to the editor and business manager of the Ohio Journal of Science, to the members of the Chapter

and to all others concerned, for the splendid co-operation which made the series of lectures so successful and which now makes their publication possible.

F. A. HITCHCOCK, *Secretary.*

Physiology Laboratories,
Ohio State University, September 8, 1933.

EDITOR'S NOTE.

The Journal is pleased to be able to publish these papers on metabolism, which form an important contribution to science, and which conform admirably to the Journal's policy of printing timely articles on topics of current scientific interest. They are published in symposium form and out of their regular order of appearance due to the financial aid of the Society of the Sigma Xi.

THE DEVELOPMENT OF METHODS FOR DETERMINING BASAL METABOLISM OF MANKIND

THORNE M. CARPENTER,
Nutrition Laboratory, Carnegie Institution of Washington,
Boston, Massachusetts.

When we breathe, oxygen is absorbed from the air in the lungs and carried by the blood to all parts of the body. The oxygen unites with the protein, fat, and carbohydrate available, produces carbon dioxide and water and in this oxidation process heat is generated. Lavoisier (1), in 1777, discovered that animals confined in an enclosed space absorbed oxygen from the enclosed air and gave off carbon dioxide. Later he and La Place (2) found that the heat given off by a guinea-pig in an ice calorimeter nearly equalled that which would be produced in the same length of time by the oxidation of the carbon equivalent to that given off in the carbon dioxide produced by the guinea-pig. They thus established a relationship between direct and indirect calorimetry. In 1789 Seguin and Lavoisier (3) made their respiration experiments on man without food at two environmental temperatures, thus determining the first basal metabolism values on a human subject. We do not have all the details of the apparatus used, but we know that a face mask was employed and that the expired air was collected and then analyzed for oxygen and carbon dioxide. Since that time various methods have been used to measure the products of combustion in the body, the carbon dioxide excreted or the oxygen absorbed, or directly the heat eliminated. I shall mention some of the methods with respect to various types that have been developed and modified from the time of Lavoisier to the present day. It is impracticable to describe in detail all of the apparatus used, but I hope to show in a general way the gradual development of the methods and apparatus up to the present-day simplifications and refinement.

Allen and Pepys (4), in 1808, described an apparatus in which the subject breathed through a mouthpiece. By means of valves operated by hand, the subject inspired from a gasom-

eter with water as a seal and expired into gasometers with mercury as a seal. Only the carbon-dioxide production was measured.

Andral and Gavarret (5), in 1843, used a copper mask with rubber edges, which could be fitted to the face. This had valves which prevented the subject from expiring into the outside air. A tube was connected to a series of glass globes in which a vacuum had been established before the experiment began. The expired air was collected by suction, and subsequently the carbon dioxide in this air was absorbed and the increase in weight of the absorption train determined.

Smith (6), in 1859, used a metal mask with valves, a meter to measure the inspired air, and containers with sulphuric acid and potash solution to absorb water vapor and carbon dioxide. Figure 2 shows the arrangement of the apparatus. The box container for the potash solution and the sulphuric acid container following it were weighed to obtain the output of carbon dioxide.

C. Speck (7), in 1871, used a pair of gasometers, one for the inspired air and one for the expired air. A nose clip closed the nostrils, and breathing took place through a tube placed in the mouth. Valves were employed to separate inspired and expired air. The changes in the weights of the bells of the gasometers were compensated by decrease and increase in weights in the counterpoises. A sample of expired air was analyzed for both carbon dioxide and oxygen.

Regnard (8), in 1879, collected the expired air in a rubber bag of about 200-liter capacity. The breathing was through a mouthpiece, and the inspired air was separated from the expired air by valves. A sample of the air in the bag was later analyzed. The modern counterpart of the bag method is the wedge-shaped bag devised by Douglas (9) in 1911. This is transportable and may also be used in rest experiments. The chief criticism against the use of rubber for collection of expired air is its permeability to carbon dioxide. This has been recently overcome by Mueller (10), who coated the inside of the bag with tinfoil and then vulcanized it.

In 1887 Geppert (11) reported measurements of the total expired air by a wet meter and had an arrangement for drawing duplicate proportional samples directly into a gas analysis apparatus. The samples were subsequently analyzed for carbon dioxide and oxygen.

Hanriot and Richet (12) in 1891 adopted a principle in the determination of the respiratory exchange that is very simple theoretically. They employed three meters in series. The first meter measured the volume of inspired air, the second meter measured the volume of expired air, and the third the volume of expired air after the carbon dioxide had been absorbed. The difference between the first and third meters gave the volume of oxygen absorbed. A mask and Mueller (water) valves were used for separating inspired and expired air.

Scharling (13), in 1843, had a chamber of 1 cubic meter content suitable for humans. It was ventilated by an air pump or aspirator, and the entire air was conducted through a potash solution to absorb the carbon dioxide. The ingoing air was also freed from carbon dioxide by a potash solution.

Pettenkofer (14), in 1862, constructed a chamber large enough for a man to remain in it 24 hours or more. The chamber was continually ventilated, and the ingoing and the outgoing air were continuously sampled proportionately for carbon dioxide and water vapor. The water vapor was absorbed by sulphuric acid and the carbon dioxide by barium hydroxide, which was afterward titrated. The total ventilation through the apparatus and sampling arrangements was measured by gas meters.

Liebermeister (15), in 1870, constructed a chamber suitable for a man, and of such a shape that the subject could sit or recline. The chamber was ventilated, and the carbon-dioxide production was determined periodically in small samples of the outgoing air by absorbing the carbon dioxide in a barium hydroxide solution and later titrating the solution with oxalic acid. He then constructed a graph of the changes in composition of the outgoing air and by means of a differential equation expressing the relationship between the ventilation, the time elapsed between samples, and the carbon-dioxide content of the outgoing air, he was able to calculate the carbon-dioxide production.

The principle of determining the respiratory exchange with a chamber by conducting air through the chamber and passing samples of the ingoing and outcoming air through absorbers as applied by Pettenkofer and Voit, has been employed by a number of other workers. The early form of the respiratory calorimeter in Middletown, Connecticut, described by Atwater, Woods, and Benedict (16) in 1897 utilized this principle. A

special pump was devised for withdrawing an aliquot of the air leaving the chamber, and this aliquot was subsequently passed through absorbers for water vapor and carbon dioxide. This chamber was large enough for a man to live in for days and weeks at a time.

In 1903 Jaquet (17) described an irregular shaped chamber of such a size that a man could either sit in the apparatus or could recline upon a bed. The outcoming air was measured by means of a gas meter, and an aliquot sample was taken for analysis. This was subsequently analyzed for carbon dioxide and oxygen.

In 1910 (18) Grafe published a description of his respiration chamber for bedridden patients only, the top of which could be raised easily in order to roll in a patient on the bed. In 1909 (19) he also described his head respiration apparatus, an arrangement that covered the head and shoulders of the patient. Both of these apparatus of Grafe were ventilated on the open-circuit principle, and an aliquot sample of the outcoming air was analyzed for carbon dioxide and oxygen.

A chamber of large size that would hold more than one person was constructed by Sondèn and Tigerstedt (20) and described in 1895. Only the carbon-dioxide production was determined with this chamber apparatus. In 1919 Benedict (21) reported the construction of a large group chamber capable of holding at least twelve individuals in bed, by which the carbon dioxide elimination of a group could be determined. The aliquoting of the outgoing air was by a unique principle.

Not only did Lavoisier study the respiratory exchange by the open-circuit principle but also he made some experiments on the respiratory exchange of animals in a closed system. This principle, however, was not carried out with man until a number of years later.

The principle of the closed-circuit system of Regnault and Reiset (22) was applied to man by Hoppe-Seyler (23) in 1894. The carbon dioxide was absorbed from the air by means of a potash solution, and oxygen was admitted to the system through a gas meter. The carbon dioxide was afterwards driven off from the potash solution by means of sulphuric acid and absorbed in an apparatus for carbon dioxide, and the apparatus was weighed. The oxygen used was obtained from the readings of the gas meter and from an analysis of the air in the respiration chamber.

In 1905 (24) the respiration calorimeter at Middletown, Connecticut, was brought to a state where the respiratory exchange of man in a chamber could be determined in short periods of from one to six hours with a high degree of accuracy. Subsequently the general principle and mechanical arrangements used in this apparatus were applied to the construction of respiration calorimeters in the Nutrition Laboratory (25). With the closed-circuit system of both the Middletown and Boston calorimeters the water vapor elimination and the carbon-dioxide excretion were determined by absorption in weighable containers, correcting for the changes in composition of the air in the closed system from the beginning to the end of the period. Oxygen was admitted from a weighed cylinder and the oxygen absorption determined from the changes in composition of the air in the system and the oxygen admitted from the weighed cylinder. In 1913 (26) observations were begun at Bellevue Hospital, New York, with a closed-circuit respiration calorimeter for bedridden patients constructed by the Russell Sage Institute of Pathology on the same general principle as the respiration calorimeters in Boston.

In 1909 appeared the first description (27) from the Nutrition Laboratory of a respiration apparatus for the determination of the respiratory exchange and respiratory quotient of man in short periods. This apparatus was the outcome of the application of the principle used in the large respiration calorimeters in Wesleyan University at Middletown and in the Nutrition Laboratory at Boston. The general principle was the determination of the carbon-dioxide elimination by absorbing it in soda-lime in weighable containers. Oxygen was admitted to the apparatus from a weighed cylinder to compensate for the amount absorbed by the subject, and the indicator for the admission of oxygen was the rise and fall of a bathing cap connected with the circulating air. The attachment to the subject was made by means of pneumatic nosepieces. This respiration apparatus was subsequently improved (28) and the bathing cap was replaced by a spirometer, the movements of which were recorded on a kymograph, thus giving an index of the character of the respiration. The volume of oxygen admitted was determined not by weighing the cylinder containing the supply, but by passing the oxygen through a carefully calibrated meter. This apparatus was called the "universal respiration apparatus" because the same arrangement

could be used for short periods with man, or could be attached to a chamber for obtaining the respiratory exchange of an animal.

In 1916 Benedict and Tompkins (29) described a clinical respiration chamber principally designed for the accurate determination of the respiratory quotient in periods of one hour or longer. This utilized a form of the universal respiration apparatus, but the chamber was of the smallest capacity that could be used and still have a subject comfortable inside it.

In 1918 Benedict (30) reduced the universal apparatus to a much smaller form. Calcium chloride was used instead of sulphuric acid for absorption of water vapor, and the apparatus was so compact that it was transportable, that is to say, it could be moved from one room to another in a hospital without dismantling and without extra assistance. This still permitted the determination of the respiratory quotient as well as the oxygen absorption.

In 1920 (31) the portable or transportable apparatus was somewhat more simplified by eliminating the determination of the carbon-dioxide excretion and making the apparatus suitable for the determination of oxygen only. This apparatus was strictly portable, as it could be shortened or altered in such a way that transportation could be made by hand.

A simple and inexpensive apparatus for use by students was described by F. G. and C. G. Benedict (32) in 1923. The inauguration of the studies on racial metabolism led to the development of a field form of the student apparatus that could be easily disassembled, transported, and reassembled in the field for use in measurements of the metabolism of different races (33). This has proved of immense practical value and has functioned satisfactorily in studies of the basal metabolism of different racial groups all over the world and under unusual conditions.

The closed-circuit apparatus for the determination of the respiratory exchange of man in short periods has found wide application in European laboratories as well as American institutions. During the last decade a number of modifications have been devised, with especial reference to the determination of both carbon dioxide and oxygen. Among these may be mentioned those of Hagedorn (34), of Knipping (35), and of Helmreich and Wagner (36) in 1924, and those of Dethloff (37), and of Dusser de Barenne and Burger (38) in 1925. However,

we have come to the conclusion that the best method of determining the respiratory quotient, when this is necessary, is by the use of the helmet of Benedict (39) with an open-circuit apparatus, two blowers, and a spirometer or bathing cap, and meters. An aliquot sample is analyzed by the gas-analysis apparatus devised in the Nutrition Laboratory (40). With this apparatus it is possible to determine the carbon-dioxide and oxygen content of air to 0.003 per cent. Hence the apparatus can be ventilated at a rate rapid enough so that the carbon-dioxide content of the outcoming air will be under one per cent. This system gives the optimum opportunity for normal breathing and repiratory quotients with a high degree of accuracy.

Each one of us is losing weight at the present moment. On the average this loss amounts to about one-half gram per minute. This loss in weight, which is called the "insensible perspiration," is due to the fact that the sum of the vaporization of water and the elimination of carbon dioxide is greater than the absorption of oxygen. F. G. Benedict (41) has been investigating this loss in weight for a number of years. By means of a delicate balance he was able to measure the loss of a subject in periods as short as 10 minutes. In a cooperative research with Dr. H. F. Root (42) at the New England Deaconess Hospital in Boston, a relationship has been established between the hourly insensible loss and the metabolism. This method of estimating the basal metabolism promises to be useful with patients who can not or will not tolerate a direct measurement of the respiratory exchange.

Thus far we have dealt only with apparatus for determination of the respiratory exchange. At the beginning of this lecture I pointed out the connection between respiratory exchange and heat production first conceived by Lavoisier. Relatively few apparatus have been constructed for the direct determination of heat elimination and heat production in man. In 1892 Atwater and Rosa (43) began the construction of a respiration calorimeter at Wesleyan University, Middletown, Connecticut. Subsequently this was brought to a high state of perfection by Atwater and Benedict (44). In 1907 and 1908 calorimeters on the same principle were built in Boston at the Nutrition Laboratory (45). One was a bed calorimeter for subjects in the reclining position, and with this many of the earlier observations on the basal metabolism of humans were

obtained. Subsequently, as mentioned before, a respiration calorimeter was constructed by Du Bois and his associates at the Russell Sage Institute of Pathology in New York, and this has been much used in studies in disease.

In 1924 Noyons (46) described a calorimeter constructed on the differential or comparison principle. For a number of years at the Nutrition Laboratory there has been in use a calorimeter for humans on the differential or comparison principle. Although the observations with calorimeters have not been so numerous as those with the respiration apparatus, they have been of fundamental importance in establishing the general principle that the heat production obtained by the indirect method, that is, from the respiratory exchange, is comparable with that obtained directly by the calorimeters.

Choice of apparatus. In the determination of the basal metabolism, one of the first problems encountered is the choice of apparatus. Should one buy a simple portable type of apparatus for the measurement of oxygen absorption only, or should one secure more complicated apparatus necessitating a gas-analysis apparatus and gasometers for the open-circuit method and for the determination of the respiratory quotient? Only a few institutions determine the basal metabolism by the direct measurement of heat production, because of the large amount of funds and the large personnel required for such observations. Before considering the question of the apparatus to secure, we should have in mind what we are trying to measure. In the body three classes of substances are burned, protein, fat, and carbohydrate. Each of these has a specific amount of heat production per unit of material, and in the process of generating heat, carbon dioxide is produced as the result of oxidation and oxygen is absorbed in order to carry on the process. Table I shows the volume of carbon dioxide given off and oxygen absorbed and the heat produced in the body in the combustion of 1 gram of each of these three substances. Now we may measure directly the heat elimination and with suitable correction for the change in body temperature we may obtain the heat production, but as already pointed out, this is an expensive and complicated procedure. At the present time, therefore, the heat production is usually determined indirectly, that is, by measurement of the respiratory exchange. Along with measurements of the carbon-dioxide production and the oxygen consumption, some investigators

also determine the nitrogen eliminated in the urine, since the latter comes specifically from the metabolism of protein. From these measurements the heat production is calculated as follows: The grams of nitrogen in the urine are multiplied by the factor 6.25 to obtain the grams of protein burned. The value for grams of protein burned is then multiplied by the theoretical volume of carbon dioxide produced and by the theoretical volume of oxygen absorbed in the combustion of one gram of protein. The volumes of carbon dioxide and oxygen thus obtained are substracted from the measured total volume of oxygen consumed and the measured total volume of carbon dioxide produced. The results represent the sums, respectively,

TABLE I.

GASEOUS EXCHANGE AND HEAT PRODUCTION OF CARBOHYDRATE, FAT, AND PROTEIN.

(Amounts per gram.)

NUTRIENT	CO_2 cc.	O_2 cc.	R. Q.	CALORIES
Human fat	1,420	1,990	0.713	9.54
Glycogen	829	829	1.000	4.20
Protein	774	957	0.809	4.40

of the carbon dioxide production and the oxygen absorption due to the combustion of carbohydrate and fat. By means of simultaneous equations we may then calculate the weights of fat and carbohydrate burned. Finally, from the known caloric values of protein, fat, and carbohydrate we can determine the heat due to the combustion of each of the three substances. The sum of these heat values gives the total amount of heat produced as obtained by the indirect method.

This method necessitates time-consuming and tedious calculations in addition to the measurement of the respiratory exchange and the determination of the nitrogen in urine. If all basal metabolism measurements required this complicated procedure the number of metabolism measurements that could be made would be reduced considerably. An alternative method is to measure both the oxygen consumption and the carbon-dioxide production but to disregard the protein metabolism because it usually constitutes only 15 per cent of the total metabolism and because in the combustion of protein the caloric

value of oxygen per liter is nearly like that in the combustion of fat and of carbohydrate and the respiratory quotient is between that of fat and that of carbohydrate. A third and still simpler method is to disregard the determination of the respiratory quotient and measure only the oxygen absorption. The question arises as to what justification there is for either neglecting the protein or for assuming that one can obtain reliable and accurate results from the measurement of oxygen absorption alone. A number of writers on the subject of metabolism have pointed out that there is a wide variation in the possible ranges of respiratory quotients and have implied that there is the same wide range, percentagewise, in the heat production under the different respiratory quotients. However, one can see from the values in the table that between the quotients of 0.70 and 1.00 the range in caloric value of oxygen is not over 7 per cent. Hence it is the usual practice to calculate the heat production from the measured oxygen consumption, using the caloric value of oxygen at an assumed respiratory quotient of 0.82, namely, 4.825 calories per liter.

The question is, how close do we obtain the true heat production from the determination of the oxygen consumption alone? To answer this question, we have calculated, from an example from our own work, the heat production according to the three different methods of measurement just described.

EXAMPLE OF THREE DIFFERENT METHODS OF CALCULATING TOTAL HEAT PRODUCTION.

(Values per minute.)

156 c. c. CO_2
185 c. c. O_2
0.84 R. Q.

Nitrogen in urine
0.00625 gram

Heat production calculated from

Protein, fat, and carbohydrate	= 0.905 cal.
Measured O_2 and measured R. Q.	= .898 cal.
Measured O_2 and assumed R. Q. of 0.82	= .893 cal.

In the example we had at our disposal for calculation the following factors: 156 c.c. of carbon dioxide per minute, 185 c.c. of oxygen per minute, with a consequent respiratory quotient of 0.84 and a nitrogen elimination of 0.00625 gram per minute. If the protein metabolism is taken into account, the heat production calculated from these figures is 0.905 calorie per minute. If we accept the idea that the respiratory quotient is necessary for the exact calculation of the heat production and use the

caloric value of oxygen at the respiratory quotient obtained in this case, we shall have 0.898 calorie. In this result we have employed the same values for carbon dioxide and for oxygen as we did in the first condition. In the third method of calculation we have used the oxygen measurement alone and have assumed a respiratory quotient of 0.82. Multiplying the oxygen figure by its caloric value for this respiratory quotient we obtain 0.893 calorie. Therefore, the three different methods of deriving the heat production give results ranging from 0.893 to 0.905 calorie per minute. One is justified in using methods that involve only the determination of oxygen for obtaining the basal heat production.

Having come to the conclusion that we are to measure the basal heat production by the indirect method and by the determination of the oxygen consumption alone, we still have further the question of selection of apparatus. For the average clinic the Roth modification (47) of the Benedict apparatus would appear to be the simplest form. This, however, requires effort on the part of the subject to open valves and to raise and lower a spirometer. For the most normal breathing conditions, we believe that an apparatus with a motor device is more suitable. Indeed, the best for this purpose is the apparatus modified in recent years by Benedict (48), in which a soda-lime container and a rotary blower are used and a spirometer serves as a dead end to the system. If a helmet is used as a breathing appliance instead of the mouthpiece, there is the greatest freedom from annoying conditions such as flow of saliva, uncomfortableness of the mouthpiece and particularly the noseclip. In recent series of observations, the helmet has been shown to be reliable and extremely comfortable, in fact, practically all individuals who have tried it prefer it to the mouthpiece. All apparatus of the spirometer type should have in connection with them a kymograph record of the excursions of the spirometer bell. If funds are limited, or if the work is in the field, and great portability is desired, the Benedict field respiration apparatus (33) is undoubtedly extremely useful. Indeed, this apparatus has proved itself of value already in a number of investigations in the field, notably in the West Indies and in Yucatan.

Normal test of apparatus. Every laboratory working on the determination of basal metabolism should test the accuracy of its apparatus with a normal subject. When the fact is once

established that the apparatus will give results on this normal subject within what is considered the normal range, this same subject's metabolism should be measured periodically in order to control the continued correct functioning of the apparatus. It is not sufficient to test the apparatus solely at the beginning of a series of measurements or when it is first installed. This subject should be called upon to act as a control whenever there is doubt as to the measurements which have been made upon a patient, and when such a person is used as a control the test should be made under as nearly as possible the same conditions as those which prevailed when apparently abnormal results were obtained with a patient. As Du Bois has pointed out, no work is better than its controls.

Theoretical test of apparatus. The best theoretical test of any type of respiration apparatus is the burning of a definite quantity of ethyl alcohol. The most all-round useful apparatus for this purpose is the combination of kymograph (49) or windshield wiper (50) and burette and spirometer, in which the small spirometer acts as a breathing apparatus and the burette is raised gradually so that the amount of alcohol burned can be measured.

Testing of apparatus during experiment. Much of the earlier work has been vitiated by the lack of an adequate test for the tightness of the apparatus during the actual measurement. With the closed-circuit and spirometer unit this test can be easily made by placing 30 grams (51) on the spirometer bell and observing whether there is any change in the level of the bell, either as indicated by the kymograph curve or by readings on the millimeter scale of the spirometer. If the slope of the kymograph curve or the curve of the plotted readings during that portion of the period when the weight is on the bell is different from the slope of the curve when the weight is not on the bell, this is proof of the presence of a continuous leak. The occurrence of an occasional leak (such as might be caused by the opening of the mouth or, in the case of the helmet, by movement of the head so that a slight opening is temporarily made in the closure around the neck) will be shown only on the kymograph record and will be indicated by a change in the trend of the curve.

Calculation of results. For the calculation of results a large number of charts, tables, nomograms, and other aids are now available. These are useful for saving time, but anyone who

is using a metabolism apparatus should be familiar with and capable of carrying out the calculations without the assistance of the charts and nomograms, even to the extent of doing all the calculations by arithmetic. This is particularly true with regard to technicians who have little knowledge frequently as to the significance of the figures that they are using, and who would in many cases never recognize ludicrous errors in either observations or calculations. It ought to be a regular routine in a laboratory for the operator periodically to carry out calculations by the long process, in order to have a thorough understanding of the methods of calculation and to acquire the ability to recognize abnormal figures when they are recorded.

CONCLUSION.

We have thus traced, in outline at least, the development of the modern respiration apparatus for the determination of basal metabolism of man. We have seen that with extremely simple and relatively inexpensive apparatus, the fundamental observations of the basal metabolism of man can be made in a relatively short period of time. However, we must not be misled by the idea that because the procedure is simple, a lack of rigid, careful attention to details of technique can be tolerated. We should regard the determination of basal metabolism with just as much seriousness of purpose as we would the more complicated and more laborious researches on the balance of income and outgo of matter and energy, from which today's simplification of technique is a logical descendant.

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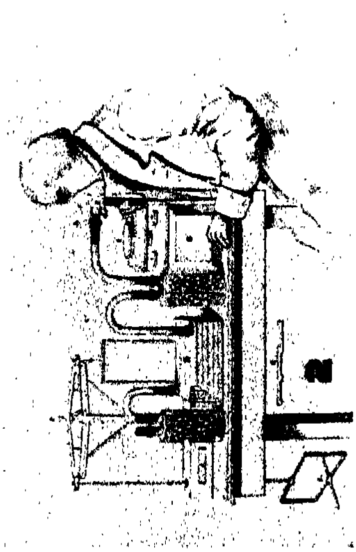

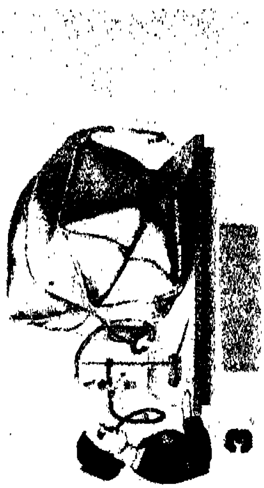

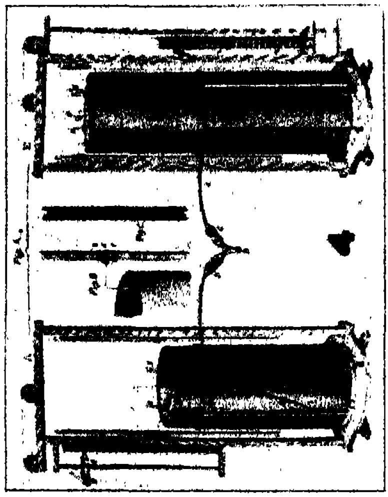

RESPIRATION APPARATUS

Fig. 1. Apparatus of Lavoisier and Seguin (1789).
Fig. 2. Apparatus of E. Smith (1859).
Fig. 3. Apparatus of P. Regnard (1879).
Fig. 4. Apparatus of C. Speck (1892).

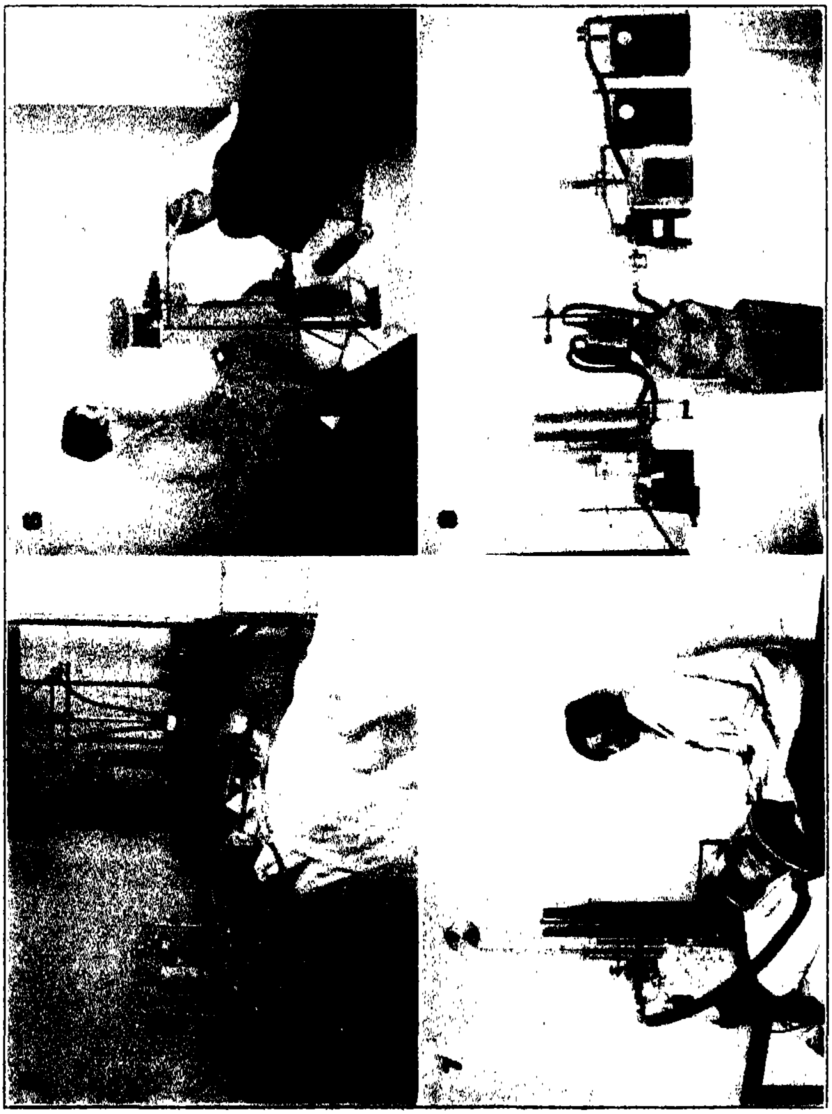

Fig. 5. Closed-circuit respiration apparatus (Benedict, 1909).
Fig. 6. Field respiration apparatus (Benedict, 1927).
Fig. 7. Helmet with closed-circuit respiration apparatus (Benedict, 1930).
Fig. 8. Helmet with open-circuit respiration apparatus (Benedict, 1933).

PROBLEMS IN THE DETERMINATION OF THE BASAL METABOLISM OF MAN AND FACTORS AFFECTING IT

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Our lives are continually maintained by the processes of heat production. As long as we produce heat, we are alive, and when heat production stops, living ceases. Thus the end result of our various activities is heat production. There is a minimum level of heat production below which we can not live for any length of time. This minimum level of heat production is the result of internal glandular and cellular activity, and of respiration and circulation. When we measure this heat production with the body in a resting, quiet condition without external muscular activity, and after the effects of the last ingested food have ceased, we call it the basal metabolism. We shall consider in this lecture some of the problems in the measurement of basal metabolism and some of the factors that affect the basal metabolism.

Effect of neutral bath. Ordinarily the basal metabolism is measured with the subject in a comfortable condition so far as the sensation of cold or warmth is concerned. In the laboratory this usually means with the ordinary clothing and, if the temperature is about 20° Centigrade, there may be a light covering of blankets. Usually, however, the amount of clothing and covering of the subject during basal metabolism measurements is not reported by the investigator, and Lefèvre (1) has criticized this procedure. He maintained that in practically all basal metabolism measurements, as ordinarily made, the conditions for heat loss are such that the metabolism is higher than the true basal. According to him the true basal metabolism can be obtained only when the subject is immersed in a water bath at 35° to 36° C., because under other conditions there will be an excess heat production to combat the loss of heat to the environment. To meet this criticism tests were made by F. G. and C. G. Benedict (2) with several subjects in which the basal metabolism was first determined

with the subjects lying clothed and lightly covered at a temperature of 15°, in order to accentuate the possible influence of a cool environmental temperature. After these measurements were made, the subjects entered a neutral bath at 34° to 35° C. in a warm room and the observations were repeated under these conditions.

The results in Table I indicate that there was no decrease in the metabolism due to immersion in a bath at nearly body temperature. If anything, there was a slight tendency to an increase in the metabolism. After the bath the subject's metabolism returned to the basal value quickly. The contention of Lefèvre was thus not substantiated. It is obvious that the determination of basal metabolism by immersion in a

TABLE I.

MR. B; AGE, 47 YEARS; NUDE WEIGHT, 67 KG.; HEIGHT, 169 CMS.

(Oxygen consumption in c. c. per minute.)

DATE	BASAL (Room Temp. 16°–18° C.)			BATH AT CIRCA 36.0° C.					
October 4..........	204	205	197	208	215	210	202	......	......
October 5..........	203	207	200	211	222	223	224	230	......
October 6..........	196	220	213	212	213	215	211	236	224

bath would be highly impracticable. Furthermore, the tendency for the metabolism to increase during the bath emphasizes the necessity for not having too heavy covering on the subject, as this might lead to a physiological fever with a consequent rise in metabolism.

Minor muscular movements. It is generally recommended that the subject remain perfectly quiet during the period of measurement. It is difficult for some people to understand what perfectly quiet means. They are apt to change the position of the legs, or to raise the hand to the face to scratch, if a slight itching or irritation takes place. One always seems to have a desire to do these things just at the wrong time. Lefèvre of Paris criticized the emphasis laid on the complete absence of muscular activity and calculated from the foot pounds required to raise the hand to the head that it would require an extremely small amount of energy. In order to test the effect of slight movements on the metabolism, F. G.

and C. G. Benedict (3) studied two well-trained subjects in the Nutrition Laboratory in which measurements were made under basal conditions and then during periods when the subject raised the hand to the forehead every four seconds. The results are shown in Table II.

TABLE II.

INFLUENCE UPON THE OXYGEN CONSUMPTION OF SMALL MUSCULAR MOVEMENTS OF ARMS AND LEGS.

Subject A			Subject B		
Date and Condition[1] 1924	Period	Oxygen Consumption per Minute c. c.	Date and Condition[1] 1924	Period	Oxygen Consumption per Minute c. c.
January 3			February 29		
Basal	I	193	Basal	I	256
Basal	II	188	Basal	II	255
Arm movement	III	218	Basal	III	253
Basal	IV	195	Arm movement	IV	280
January 7			March 1		
Basal	I	200	Basal	I	257
Basal	II	196	Basal	II	255
Arm movement	III	210	Basal	III	244
Basal	IV	193	Arm movement	IV	268
Leg movement	V	222	Leg movement	V	285
January 9					
Basal	I	203			
Basal	II	189			
Arm movement	III	224			
Leg movement	IV	209			
Basal	V	189			
January 16					
Basal	I	202			
Basal	II	195			
Arm movement	III	215			
Leg movement	IV	225			
Basal	V	200			

[1]In basal periods subjects were lying, clothed, and covered with light blanket. In the arm movements the hand was raised to the forehead every 4 seconds. In the leg movements the feet were crossed every 20 seconds.

The actual increase proved to be only 1.5 cc. of oxygen for each movement. In another series, the subject crossed and uncrossed the legs every 20 seconds. One such leg movement every minute would raise noticeably the basal metabolism. Although single minor muscular movements, such as raising the arm to the head, have but little influence on the basal

metabolism, movements of the legs must be denied. It is unsafe to disregard any of the stringent rules for quiet muscular repose. It is best to do everything possible to get the subject into a comfortable, relaxed position so that there will be no desire to change the position. The operator should have everything as free as possible from little annoyances, such as wrong lights, jarring the bed, and slamming doors.

Effect of previous activity. Benedict and Crofts (4) showed that the basal metabolism was not raised by the muscular exercise of rising, bathing, dressing, walking in wintry weather for 10 minutes, and climbing 3 flights of stairs, provided that

TABLE III.

Oxygen Absorption and Pulse Rate Per Minute of College Women Before and After Rising.

Subject No.	Oxygen Absorption		Pulse Rate	
	Before Rising	After Rising	Before Rising	After Rising
	c. c.	c. c.		
II	243	249	56	51
III	193	196	65	63
IV	190	200	56	55
V	173	175	57	56
VI	170	170	59	56
VII	182	186	59	57
VIII	170	165	62	58

after such exercise the subject was clothed and lay quietly for 30 minutes, lightly covered, in a room at circa 20° C. Values secured under such conditions were compared with those obtained after a night's sleep in bed before the subjects arose and went through the activity previously described. Table III gives a summary of the results.

Constancy from hour to hour. Some of the questions that arise in connection with the determination of basal metabolism are, how many periods of measurement shall there be on the same day, and how shall we make a selection from the results, or shall we average all that we obtain? Certainly we should not depend on one observation and it is better to have three periods, if possible. Then we may consider the first period as one of adjustment and average the results of the other two. Some years ago, in a study of the comparative accuracy of

different types of respiration apparatus, (5) I came to the conclusion that in three successive periods the oxygen consumption should not have a greater range than 10 c.c. This would mean a 5 per cent range, if the average oxygen consumption were 200 c.c. per minute. Since that time I have come to the conclusion that this is too rigid a standard to demand in all cases, and that with untrained subjects a greater range would have to be allowed, probably 15 c.c. at a level of 200 c.c. per minute. As a general rule, it is not wise to make observations for more than three periods, rejecting the first if materially higher than the others, or averaging all three. Subjects usually become fatigued or restless after three periods,

TABLE IV.

CONSTANCY IN BASAL METABOLISM IN CONSECUTIVE 10-MINUTE PERIODS.

(Mr. C., January 26, 1925.)

Period	Oxygen Consumed Per Minute	Period	Oxygen Consumed Per Minute
	c. c.		c. c.
I	219	VII	225
II	220	VIII	229
III	219	IX	223
IV	230	X	223
V	223	XI	222
VI	225		

and then the metabolism rises. Table IV shows that with a well-trained subject it is possible to obtain a series of 10 periods with a narrow range in values (6).

Constancy from day to day. Not only are we concerned in the constancy of the basal metabolism on the day of measurement, but also the range of values from day to day is of importance in any study of metabolism. It is the practice in some laboratories to determine the basal metabolism on several days and then use the average of these days' measurements as a base-line for comparison with measurements under other conditions on days when the determination of the basal metabolism is omitted. This may be justifiable when the effect of the superimposed factor is large, but hardly acceptable when only slight differences are expected. As a rule, rarely, if ever, do we use an average basal value derived from measurements on several days to calculate the effect of a superimposed factor.

It is always best to determine the basal metabolism on the same day and under the same conditions as those under which the superimposed factor is to be studied. In 1921 a statistical analysis made by Harris and Benedict (7) on 11 subjects who had been studied from 20 to 53 days led to the general finding

TABLE V.

VARIATIONS IN OXYGEN ABSORPTION FROM DAY TO DAY.

SUBJECT	NUMBER OF EXPERIMENTS	RANGE OF O_2	AVERAGE O_2	COEFFICIENT OF VARIATION
		c. c.	c. c.	
J. C.	40	198–231	210	3.4
J. C.	55	202–235	215	3.5
J. C.	31	207–232	222	2.4
J. C.	36	210–251	227	3.4
C. M. B.	41	238–283	257	3.6

of a coefficient of variation of 4 per cent of the average metabolism. During the past few years we have had several series of experiments with one subject and one series with another varying from 31 to 55 days. Table V shows the results, which are of about the same order as those obtained by Harris and

TABLE VI.

CONSTANCY IN BASAL METABOLISM ON CONSECUTIVE DAYS.

(Mr. C.)

DATE	OXYGEN CONSUMED PER MINUTE	DATE	OXYGEN CONSUMED PER MINUTE
	c. c.		c. c.
April 21........	217	May 5.......	216
April 22........	215	May 10.......	225
April 23........	214	May 19.......	221
April 24........	218	June 24........	226
April 25........	229	June 25........	219
April 28........	222		

Benedict. The highest result with C. M. B. was on the first day. In all of the measurements this subject was sitting but post-absorptive, as was also J. C. in the third series. An example of low daily variation is shown in Table VI, (8) when J. C. was studied on 11 different days.

Seasonal variations. In the course of the year there are marked variations in the external temperature, which in our latitude ranges from 100° F. in the shade with high humidity in summer to 10° below 0° F. with low humidity in winter. We try to accomodate ourselves to these conditions by change in amount and character of clothing, to some extent by lessening activity in summer, and also by an attempt at artificial cooling (consumption of iced drinks and foods). The question, however, arises as to whether there may not be a seasonal variation in basal metabolism which may occur in spite of our attempts to adapt ourselves to climatic and seasonal changes. In order to obtain some information on the possible occurrence of a seasonal variation, Gustafson and Benedict (9) made a

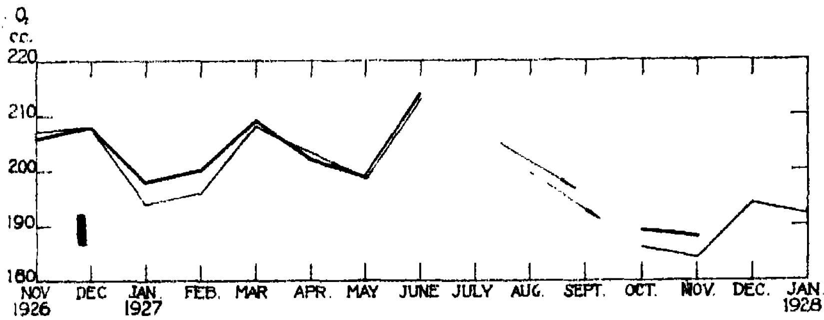

FIGURE 1. Course of the oxygen consumption of young women with the change in season. The light black curve represents the average for five subjects, the heavy black curve that for eight subjects.

series of measurements of the basal metabolism of 20 Wellesley College students once each month from October, 1926 to January, 1928 with the exception of July, August, and September. In Figure 1 the light line curve shows the course of the average basal oxygen absorption of five young women and the heavy line curve that of eight subjects. There was a low metabolism during the winter followed by a higher level in the spring. The low level in May may possibly be due to the relatively large number of observations during menstruation. In the course of a series of measurements on a well-trained male subject we have observed that the metabolism tends to be higher in the spring than at any other time. The cause for the change in metabolism is not known. It can scarcely be due to a rise in external temperature, as the temperature is higher later in the year.

Menstruation. When the basal metabolism of normal women between the ages of puberty and the menopause is determined, it is usually recommended that the observations be taken on days outside the menstrual period. A number of studies have been made on the basal metabolism during the menstrual period as compared with that during the non-menstrual interval. Hitchcock and Wardwell (10) in this institution have reported a series of 800 tests on 27 women. Selecting the results on 20 women, they found that 14 showed a lowering of the basal metabolism during the menstrual period. Benedict and Finn (11) studied the day to day varia-

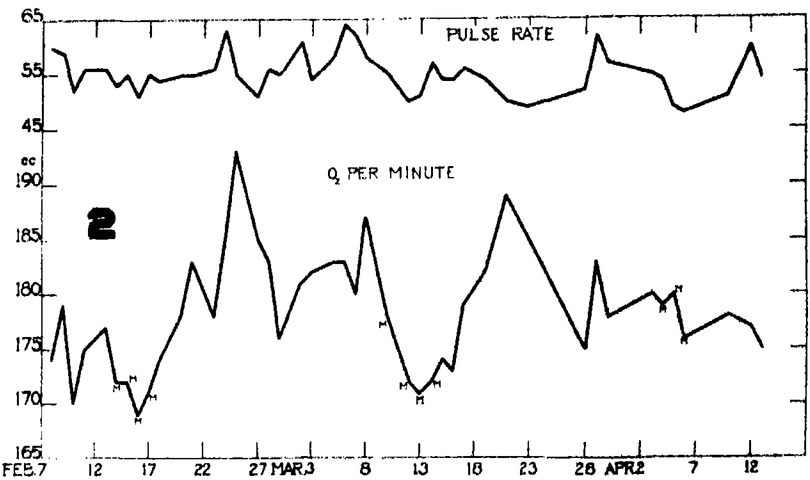

FIGURE 2. Oxygen consumption (cc.) and pulse rate per minute of Miss W. from day to day throughout a period of two months, including three menstrual cycles. The menstrual days are indicated on the oxygen curve by the letter M.

tion on a well-trained subject for two months, including three menstrual cycles. Figure 2 shows the daily variations in oxygen absorption and pulse rate for this subject covering more than two months. The menstrual days are designated M. In all three menstrual periods the metabolism was lower than that obtained during the remaining portion of the month.

Metabolism before and after vacation. In the course of a number of years, observations have been made on the metabolism of members of the staff of the Nutrition Laboratory (12) before vacation, usually in July, and then again as soon as possible on their return to laboratory activities, usually in September. The number of subjects studied varied from year

to year, and a series of observations was made in 4 different years, 1918, 1920, 1925, and 1927. In Table VII is given a summary of the average results obtained each year. The groups were not the same each year, and consequently the average values vary. The table includes data on the body weights and the pulse rates as well as the oxygen absorption. In general, most of the individuals gained weight during the vacation although this was not invariably the case. In some cases there were gains of as high as 4 kilos during vacation. This is reflected in the general average of the body weights. In spite of this, however, the averages for three of the four groups indicate practically no change in the oxygen absorption measured in the basal condition.

TABLE VII.

AVERAGE BASAL METABOLISM BEFORE AND AFTER A VACATION.

Year	Number of Subjects	Body Weight (kilos)		Oxygen per Minute (c. c.)		Pulse Rate per Minute	
		Before	After	Before	After	Before	After
1918.......	9	54.1	55.4	188	188	64	64
1920.......	5	56.5	58.3	195	189	65	64
1925.......	5	63.6	63.4	200	221	61	66
1927.......	9	60.8	61.3	187	190	63	62

In 1925 three of the group showed marked increases in metabolism. Thus, in one case the oxygen absorption increased from 142 to 172 cc. per minute and in another case from 254 to 273 cc., that is, gains of 21 and 8 per cent, respectively. In none of the individuals in the other three series was there any pronounced change in the metabolism. Also, in this group in 1925 there was a marked increase in pulse rate. Most of this increase, however, is due to a change in the pulse rate of one individual from 55 before vacation to 82 after vacation. One of the same subjects who showed a marked increase in 1925 also showed an increase in 1927.

These studies, however, indicate, as a whole, that the vacation does not result in any change in metabolism. This is surprising and speaks for a marked fixity in basal metabolism which seems to be unaltered even when pronounced subjective

impressions of recuperation and betterment are expressed. In view of the present fad for sun tanning it may be advisable or desirable to have additional studies in which the possible effect of exposure to sunlight is specifically studied.

Body temperature. It is well known that the metabolism is raised during fever. Du Bois (13) found that for each degree Fahrenheit rise in body temperature the metabolism was increased 7.2 per cent. The possibility of the variation in metabolism within normal range being due to variations in body temperature has been but little considered. It is our custom to take the temperature by mouth each day before any measurement of metabolism is made. This aids us in ruling out any measurement with febrile temperature. It is

TABLE VIII.

CORRELATION BETWEEN MOUTH TEMPERATURE AND OXYGEN ABSORPTION.

SUBJECT	NUMBER OF EXPERIMENTS	RANGE OF O_2	RANGE OF TEMPERATURE	CORRELATION COEFFICIENT	
		c. c.		r.	P. E.$_r$.
J. C.	40	198–231	35.8–37.1° C.	+0.502	±.080
J. C.	55	202–235	35.7–37.1° C.	+0.386	±.077
J. C.	31	207–232	36.0–36.8° C.	+0.530	±.087
C. M. B. ...	41	238–283	96.1–97.9° F.	+0.407	±.088

recognized that temperatures by mouth are not so reliable as rectal temperatures, but at least an unusually high temperature is significant even when taken in this manner. In a study of the effect of sugars on metabolism and in a study of the effect of muscular work on sugars and on the metabolism of alcohol we have completed several series of experiments in which we have had both mouth temperatures at 8:30–9:00 a.m. and basal metabolism determinations shortly after. Table VIII shows the number of observations, range of oxygen absorption and of mouth temperatures, and the correlation coefficients between mouth temperature and oxygen absorption. Although only two of the coefficients are greater than 6 times the probable error, they are all positive and in the same direction, and indicate that the metabolism varies with mouth temperatures and that the latter are of some significance as an explanation of the variations in metabolism. The temperatures

at the upper part of the ranges are probably of more significance than those at the lower end. An early morning temperature of 96.1° F. undoubtedly is erroneous, whereas a temperature of 98.2° F. is of significance. It should be noted that but rarely is a "normal" body temperature of 98.6° obtained. In fact, 98.6° at 8:30 a.m. would be regarded by us as an indication of a mild febrile condition.

Effect of sleep. One of the conditions of the measurement of basal metabolism is that the subject shall not be asleep. It would be ideal if the measurement of the basal metabolism could be made with the subject asleep, because in this condition a person would be more likely to be completely relaxed and free from possible fear. The true difference, however, in different people between the metabolism asleep and that while awake is not so definitely known that we can apply a general value for making the comparison. The measurement of the oxygen absorption during sleep is difficult to make because the character of the respiration is likely to be irregular. Sleep affects the pulse rate and the respiratory quotient as well as the oxygen absorption. In general, the decrease in the metabolism due to sleep is about 10 per cent. Until recently measurement of the metabolism during sleep has been difficult, because of the lack of a suitable breathing appliance. None of the breathing appliances used for short periods has been reliable enough to prevent leakage during sleep. The helmet recently devised by F. G. Benedict (14) now makes it possible to study the metabolism during periods of sleep and periods when the subject is wide awake.

Hypnotic sleep. Whitehorn, Lundholm, Fox, and Benedict (15) found that simple hypnotic sleep might have an influence on basal metabolism by reducing the high figures obtained in training subjects, but did not reduce the rate below the normal value. In this respect, it differs from normal sleep.

Effect of mental effort. Basal metabolism is measured when the subject is awake, and under this condition, the mind is more or less active. It may wander from one thing to another or the person may concentrate intensely on a problem he has on hand in order to disassociate himself from the measurement and to prevent himself from becoming bored. A question that is frequently asked is, does mental "work" increase metabolism? Recently F. G. and C. G. Benedict (16) conducted a series of studies on six subjects to determine the effect

of intense mental effort on the basal metabolism. The metabolism was first measured with the subject in a comfortable, reclining position, and in so far as possible, during mental vacuity. Then for one hour the subject was given mental arithmetic by a person reading problems of multiplication, such as 76 × 69. The subject signalled when the problem was solved, and was given another immediately. The metabolism was measured with the helmet respiration apparatus, both on the closed-circuit principle and on the open-circuit principle, with gas analysis. Table IX shows the effect of this intense sustained mental effort on the metabolism. On

TABLE IX.

EFFECT OF MENTAL EFFORT ON OXYGEN CONSUMED.

(c. c. per minute.)

SUBJECT	REST	WORK
I	208	210
II	212	219
III	232	241
IV	242	247
V	174	187
VI	181	191
Average	208	216

the average, the oxygen consumption was increased less than 4 per cent.

Standards of basal metabolism. For a number of years the Nutrition Laboratory collected data on the basal metabolism of normal men and women. In 1919 Harris and Benedict (17) evolved a set of prediction formulas for the average basal metabolism of men and women. These took into account the effect of height, weight and age and difference in sex. These formulas were based on metabolism data on 136 men and 103 women. Two other standards are also available, the Aub and Du Bois (18) based on body surface, and the Dreyer (19) based on age and weight. In general, the three standards give about the same results, because they are based upon practically the same original material. Benedict (20) has recently reported additional measurements on 34 men and 32 women. In both groups the average variation of the measured metabolism from the predicted was less by the Harris and

Benedict and Dreyer than by the Aub and Du Bois standards. It is found that the present standards for women are about 5 per cent too high. Benedict reiterates his belief that the heat production is determined by the active mass of protoplasmic tissue and by some existing stimulus to cellular activity. He is strongly inclined "to support the belief that differences in basal metabolism are more logically interpreted with reference to differences in age, height, weight, and sex rather than with reference to differences in surface area."

Effect of age on basal metabolism. Although the basal prediction formulas include a factor for the effect of age, this

TABLE X.

AGE AND BASAL METABOLISM. CALORIES PER KILOGRAM PER DAY.

Miss W.		H. M. S.	
Age	Calories	Age	Calories
24	23.0	43	22.8
27	22.5	48	22.8
29	22.0	50	23.0
30	22.2	59	22.0
31	22.2	64	19.7
32	22.5		
33	22.8		
34	20.9		
35	21.0		
36	20.8		
37	19.9		
41	20.3		

factor is applicable to groups as a whole. So little is known about the effect of age with given individuals that no prediction can be made at the present time as to the possible variations in the effect of age on individuals who, although increasing in years, may still be in practically good health.

The Nutrition Laboratory has had the opportunity to follow the metabolism of 4 individuals for periods of from 17 to 24 years (21). Table X shows the series of values for the heat production per kilogram per day of a woman measured over a period of 17 years and for a man measured over 21 years. On the woman the series began in 1916 and on the man, in 1911. In the case of the woman there is a slight

decrease in the metabolism per kilogram. Part of this decrease probably can be ascribed to a slight increase in weight, as she changed from a value in 1918 of 54 kilograms to a value of 60.5 kilograms in 1928.

With the man there has also been a gain, from 59 to 63.6 kilograms from 1911 to 1932, and there has been but little change in total calories per kilogram for the entire period of time.

TABLE XI.

AGE AND BASAL METABOLISM. CALORIES PER KILOGRAM PER DAY.

T. M. C.		F. G. B.	
Age	Calories	Age	Calories
30	27.8	38	22.5
32	26.4	39	21.6
34	27.8	40	21.6
35	26.6	41	20.6
36	26.9	44	20.7
40	26.5	45	21.1
42	24.6	46	20.8
46	22.8	47	21.0
49	22.9	48	20.6
54	23.5	50	21.1
		51	21.3
		52	23.3
		53	21.9
		55	20.4
		57	19.8
		61	20.1
		62	20.6

Table XI gives the results obtained on two members of the staff who have been connected with the Nutrition Laboratory since its beginning in 1907. With T. M. C. the first observations were in 1909, and there is a marked decrease in the values per kilogram from 27.8 to 23.5 calories at the age of 54. During this period of time the maximum change in weight was 3.5 kilograms, and there was an actual difference between the beginning weight and the last weight of 0.7 kilogram. The most marked decrease in metabolism was at the age of 46. The other subject shows likewise a decrease in metabolism per kilogram, but not so marked as with T. M. C. In 1917 at the age of 39, T. M. C. had typhoid fever. Whether this

had any effect on the subsequent change in total metabolism cannot be stated, although for 6 months or more there was a marked decrease in activity. At the age of 44 T. M. C. purchased his first automobile and since that time has traveled almost exclusively by automobile rather than on foot and in street cars, as formerly. It is not improbable that some of the decrease in metabolism may have been due to a decrease in activity.

F. G. B. has been an extraordinarily active man during the entire period of observation. In fact, it is due to his inexhaustible energy and capacity for work and his continuous ingenuity in devising apparatus for over 25 years that most of the material is available for the substance of these two lectures.

The actual decrease in total calories for the two men over a period of 19 years was 283 calories for T. M. C. and 310 calories for F. G. B. In the Harris-Benedict prediction formula the same decrease per year is presented, regardless of the size of the individual. Many more observations are needed to establish the variations in the effect of age on the metabolism of the individual.

Elderly women. One of the marked gaps in the available data on the basal metabolism of normal humans is the lack of measurements beyond the age of 40. Recently Benedict and Meyer (22) determined the basal metabolism of 23 elderly women from 66 to 86 years of age and weighing from 32 to 72 kilograms. These women were all presumably in good health and none of them were bedridden. Most of them took care of their own rooms and some helped in the general care of the institution where they were living. On all bases of comparison the metabolism decreases with age. Beyond 78 years one might accept as a round figure 1000 *total* calories per 24 hours. Table XII shows the results of the measurements and the comparison by the three different standards of prediction. The variations from the predicted values for the different individuals were rather wide, from +14.9 to −16.9 per cent on the Harris-Benedict basis of prediction and the average deviation for the whole group was −0.8 per cent. The predicition by the Harris-Benedict standard was closer on the average than either of the other two bases of prediction. In general, there are such wide divergences that no existing standards may be considered to predict accurately the basal

metabolism of individual elderly women. Therefore, until many more have been studied and more exactly measured the prediction of metabolism in old age may not be accepted.

Metabolism of Orientals. The standards for the prediction of basal metabolism were based entirely on observations with Caucasians, and at the time they were formulated there was

TABLE XII.

BASAL METABOLISM OF ELDERLY WOMEN.

SUBJECT	AGE	WEIGHT	TOTAL HEAT PRODUCED PER 24 HRS.	PER CENT DEVIATION		
				Dreyer	Aub-DuBois	Harris-Benedict
	yrs.	kg.	cal.			
I........	66	50	931	—18.3	—24.0	—16.9
II.......	68	71	1359	+ 1.0	— 2.0	+ 4.6
III......	70	72	1401	+ 3.6	+ 2.2	+ 7.1
IV.......	70	52	1112	— 3.6	— 3.9	+ 0.5
V........	71	72	1501	+11.2	+ 8.3	+14.9
VI.......	71	64	1149	— 9.5	— 9.9	— 5.5
VII......	71	67	1323	+ 2.0	— 5.1	+ 4.1
VIII.....	71	53	1096	— 5.3	— 8.4	— 2.1
IX.......	73	64	1318	+ 4.1	+ 0.9	+ 8.4
X........	74	63	1122	—10.6	— 9.8	— 5.5
XI.......	74	45	936	—11.5	—17.4	— 9.2
XII......	76	49	1148	+ 3.7	+ 1.4	+ 8.9
XIII.....	77	32	799	— 9.9	— 9.9	— 6.4
XIV.....	78	42	973	— 3.9	— 5.5	+ 1.8
XV......	79	69	1049	—19.5	—19.7	—14.5
XVI.....	81	67	1035	—19.0	—15.7	—12.8
XVII....	81	41	961	— 3.4	— 5.9	+ 1.6
XVIII...	84	50	1015	— 7.9	— 6.3	+ 0.3
XIX.....	84	44	1045	+ 1.4	— 3.5	+ 7.2
XX......	84	44	1070	+ 3.2	+ 5.6	+12.2
XXI.....	84	45	973	— 7.1	— 8.2	— 0.3
XXII....	84	63	966	—21.9	—19.4	—15.3
XXIII...	86	54	1026	— 9.7	— 9.7	— 2.0
GRAND AVERAGE (PER CENT)..........				— 5.7	— 7.2	— 0.8

no indication but that they were applicable to all other races. However, in 1924 and 1925 MacLeod, Crofts, and Benedict (23) made some observations on the basal metabolism of 7 Chinese and 2 Japanese women, ages 21 to 29 years, who resided either at Mount Holyoke or Columbia University. It was found that the basal metabolism of these women was from 2.3 to 16.5 per cent below the Harris and Benedict standards, on the average 10.4 per cent below. Since these

young women had been living under the same conditions as the other students at the institutions and having the same diet, it was suggested at that time that the metabolism of Orientals may be specifically lower than the English and American standards and that a racial effect in the direction of a lower metabolism be recognized with the Chinese and the Japanese.

Racial variation in metabolism. The observations of MacLeod, Crofts, and Benedict led the Carnegie Institution of Washington to undertake an extensive research in cooperation with investigators of other institutions on the basal metabolism

TABLE XIII.

MALE MAYAS IN YUCATAN. DEVIATION OF MEASURED METABOLISM FROM AMERICAN STANDARDS.

INVESTIGATOR		PER CENT DEVIATION
Williams		+5.2
Shattuck		+5.8
Steggerda:		
First Day	+9.2	
Second Day	+7.7	
Third Day	+8.2	
Average		+8.4
GRAND AVERAGE		+6.5

of a number of different races. On the occasion of an expedition to Yucatan in 1927, sent out by the Carnegie Institution of Washington and Harvard University, Dr. George D. Williams measured the metabolism of 32 male Mayas and found that the metabolism of the Mayas was, on the average, 5.2 per cent above the standards for white men of similar ages, heights, and weights (24). Three years later a second expedition to Yucatan was organized by Harvard University, working under the auspices of the Carnegie Institution of Washington. On this expedition measurements of the metabolism were made on 25 male Mayas under the direction of Dr. George C. Shattuck (25). Many of the subjects were the same as those that had been studied by Williams. The grand average deviation was +5.8% for the 25 individuals.

In a third expedition to Yucatan in 1931, carried out by the Department of Genetics of the Carnegie Institution of Washington, Dr. Morris Steggerda (26) measured the metabolism of 30 men and in order to solve the question as to whether the previous values may have been due to measurements only on one day, the observations were repeated on three different days. The grand average of all the values for percentage deviation of measured from predicted metabolism was +8.4. Table XIII shows the averages obtained on the three different expeditions. Coincident with these high values of metabolism

TABLE XIV.

FEMALE TAMILS IN MADRAS. DEVIATION OF MEASURED METABOLISM FROM AMERICAN STANDARDS.

SUBJECT	PER CENT DEVIATION	SUBJECT	PER CENT DEVIATION
1..........	—16.6	15.........	—17.3
2..........	—15.8	16.........	—26.5
3..........	—13.0	17.........	—15.0
4..........	—10.5	18.........	— 9.8
5..........	—18.1	19.........	—21.9
6..........	—19.2	20.........	—13.0
7..........	—21.4	21.........	—17.5
8..........	—16.7	22.........	—16.0
9..........	—12.3	23.........	—20.2
10..........	—20.5	24.........	—19.7
11..........	—12.1	25.........	—17.8
12..........	—18.0	26.........	—14.2
13..........	—25.2	27.........	—10.6
14..........	—29.8		

GRAND AVERAGE, —17.4

were low pulse rates, in fact, lower than usually observed with whites. In the last series many of the pulse rates were 45 or below. Similar low values were obtained by Shattuck and Williams, indicating that the high metabolism was in no way due to high heart rate.

In contrast to the metabolism of the male Mayas is the low metabolism of female Tamils measured by Professor Eleanor D. Mason at the Women's Christian College at Madras (27). Twenty-seven female Tamils were found to have invariably a low metabolism compared with the prediction. Table XIV shows the individual deviations for the 27 subjects

and the average of the group as a whole, namely, −17.4 per cent. In the same institution another group of South Indian women, 17 Malayalis, showed an average of −16.1 per cent below the standards for American women.

These studies all indicate significant differences from American standards in the metabolism of the different races. The problem of variation in basal metabolism according to race is complicated by the factors of climate and of diet. However, the climate in South India and the climate in Yucatan are not so different as to suggest that climate plays the dominant rôle in the metabolism of these two races.

CONCLUSION.

We thus see that the determination of the basal metabolism is a fundamental measurement by which we may compare groups of individuals with respect to standards of nutrition, differences in race, effect of climate, and effects of such factors as influence human beings in masses. Knowledge of the basal metabolism is of such profound physiological importance that many more and careful measurements are needed before we can formulate the general laws governing the level of metabolism of each individual. Determination of the basal metabolism is of world-wide significance because it is applicable as a measure of vital activity to each human being.

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The Universe of Light.

The rapid advances in physical science have centered largely around the phenomenon of radiation. This book, written in popular style, presents by description, analogy and experiment a clear understanding of our everyday experience with light, color, and associated phenomena. To those who, while not physicists themselves, have followed the recent popular accounts of astronomy, this book will appeal as offering a wider range of discussion and analysis.—L. H. S.

The Universe of Light, by Sir William Bragg. x + 283 pp. New York, The Macmillan Co. 1933. $3.50.

Savagery to Civilization.

The "Century of Progress" is but a step on the long long trail over which the author takes us in review of anthropology. The trail leads through the hunting life of the Old Stone Age to the pastoral life of the early tillers of the soil; through the bronze age to the dawn of history. Villages become cities, Egypt, Babylon and Crete grow and wane, and modern man emerges to carry on and continue along the trail that leads into the future. The author is to be congratulated on his ability as a guide along the trail.—L. H. S.

The Long Road from Savagery to Civilization, by Fay-Cooper Cole. One of the Century of Progress Series. xi+100 pp. Baltimore, the Williams and Wilkins Co. 1933. $1.00.

Plant Genetics.

This book fills a long-felt need for a modern, technical discussion of the subject of plant genetics. The first three chapters deal comprehensively with "Inheritance in Diploids," "The Chromosome Theory of Heredity," and "Constitution of the Factor." The latter two of these chapters present a detailed summary of the cytological basis for hereditary behavior. Following are four chapters dealing with one aspect or another of the phenomenon of polyploidy. Fundamental as this concept is to plant genetics, it has been neglected in most books in the general field of genetics. There are also chapters on "Structural Hybrids" and "Interspecific Hybridisation." The book closes appropriately with a chapter dealing largely with the species problem. This discussion is very suggestive regarding the role which genetics may attain in placing taxonomy upon an experimental basis. There is a bibliography of over a thousand titles which should prove invaluable to research workers in the field of genetics; and an index. This book will fully justify the space it occupies on the reference shelf of any botanist or geneticist.—B. S. Meyer.

Recent Advances in Plant Genetics, by F. W. Sansome and J. Philp. x+414 pp. Philadelphia, P. Blakiston's, Son & Co. 1932.

SOME ASPECTS OF CARBOHYDRATE METABOLISM

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An eminent biochemist was wont to say facetiously that he had the ambition to make a lump of sugar and to lay an egg. He lived to fulfill the first of these aspirations, but died before he had the egg quite finished. I refer, of course, to Emil Fischer. He made not only one but several kinds of sugar and together with Kossel, about the beginning of this century, he revealed the fundamental nature of proteins. In carbohydrate metabolism one cannot omit the proteins, for carbohydrate can be formed from protein and this is an important source of biotic energy. Some reference will be made to this aspect of carbohydrate metabolism, but I shall be concerned mainly with the question of the possible formation of sugar from the other principal source of energy, namely, fat.

Metabolism properly begins with digestion. Let us look just a moment at the nature of this change and particularly its rate. The nature of the change is indicated by the reaction $(C_6H_{10}O_5)n + nH_2O \rightarrow (C_6H_{12}O_6)n$. This is called hydrolytic cleavage. All of the ordinary processes of digestion are of this nature.

Digestion of starch is begun by saliva in the mouth, provided the saliva is well mixed with the food. A familiar laboratory experiment to illustrate the rapidity of the action of ptyalin, the starch splitting ferment of the saliva, is to chew a soda biscuit or cracker for two minutes, place the chewed mass over a filter paper and wash with distilled water. Applying a copper reduction test to the filtrate one gets a good reaction for sugar.

Further evidence of the rapid action of saliva is obtained by digesting in glassware cooked cereal breakfast foods. The following Table (I) illustrates:

TABLE I.

DIGESTION FOR FIVE MINUTES AFTER COOKING FIFTEEN MINUTES.

	Complete Digestion.	Digestion to Solubility.
	%	%
Wheat endosperm	22.7	70.7
Precooked oats	34.9	77.2
"Whole wheat"	26.8	67.6
"Toasted whole wheat"	31.1	66.8

Biedermann speaks of the almost "explosive action" of ptyalin in digestion of starch. If the starch be already soluble the digestion to sugar is even more rapid.

Cannon at Harvard showed about 30 years ago that digestion of starch can proceed in the stomach after a mixed meal for from 15 to 90 minutes, being stopped only when the entire stomach contents become acid. This has been confirmed by Bergeim and Hawk, who used the retention tube and drew up samples of stomach contents at various intervals after digestion started. Under favorable circumstances therefore the starch may be digested to complete solubility therefore in the stomach. Disacchrides like cane sugar need only to be inverted, i. e., split into two molecules, for single sugars to be ready for absorption—

$$C_{12}H_{22}O_4 + H_2O \rightarrow 2C_6H_{12}O_2.$$

Lusk (2) in 1898 proved that this takes place rapidly in the stomach under the influence of the HCl of the gastric juice.

When the food leaves the stomach, therefore, the carbohydrate is already pretty well digested. The process is continued speedily by the amylase of the pancreatic juice, which would suffice of itself to complete the whole series of changes, if no other enzyme were available.

We have been interested in our laboratory in the enzymes of the intestinal juice produced by the mucosa of the intestine. We have already proved that a piece of intestine transplanted (3) into the abdominal wall under the skin secretes a greater quantity of juice when the dog eats, even when there is no connection by blood vessels or nerves with the rest of the alimentary tract. Incidentally, this proves hormone control of this secrêtion. Two of the enzymes which have been studied are an intestinal amylase and a sucrase. The action is feeble compared with the enzyme of the pancreas, nevertheless they are sufficient to completely split several grams of starch and cane sugar in the course of 24 hours.

CARBOHYDRATE IN THE BLOOD.

It is clear then that we are specially equipped with a very efficient series of chemical agents to digest carbohydrates speedily—far more speedily than either fats or proteins can be digested. When digestion is complete, the starch is all reduced to glucose and the several disaccharides have been reduced to monosaccharides. Those which are not glucose, like fructose

and galactose, get transformed into glucose either in the course of absorption or in the liver, so that all the carbohydrate is glucose by the time it reaches the general circulation for distribution to all the tissues.

This sugar of the blood may be formed also from protein as was first proved by Cl. Bernard, the great French physiologist, who flourished about the middle of the last century. He was following the fate of foodstuffs which disappeared from the alimentary tract and had reached the point of investigating what happens in the liver which, you remember, receives all the blood coming from the alimentary organs through the so-called portal system. Taking blood as it entered the liver by the portal and comparing it with blood as it leaves the hepatic vein, Bernard found that when a dog had been fed a large amount of meat the liver gave up far more sugar than it received without any change in the amount retained. This could only mean that carbohydrate is formed from protein. We know now that the reaction fundamentally is as follows:

$$CH_3 \cdot CH\ HN_2 \cdot COOH + H_2O = CH_3 \cdot CHOH \cdot COOH + NH_3$$
$$2\ CH_3 \cdot CHOH \cdot COOH = C_6H_{12}O_6.$$

Alanin, a 3-carbon amino acid typical of the building stones in protein is hydrolyzed to lactic acid and from two molecules of this one of glucose can be formed. Another possible reaction is by oxidation of pyruvic acid and by reduction to glucose.

We have then at least two sources of the sugar in the blood—the carbohydrate of the food and the protein not needed for growth or repair of the tissues. The capacity of the body to handle sugar may be determined by what is called a tolerance test. Injecting a known amount of glucose at a certain rate into a vein it very quickly mixes with the whole blood and the level of blood sugar found in any vein plotted against time gives a tolerance curve. If the curve falls promptly tolerance is good; if it falls slowly, tolerance is poor. A few curves obtained on (4) normal and diabetic dogs are given later (p. 349).

The whole picture of sugar regulation in the blood is nicely illustrated by a diagram designed by Drs. Ringer and Baumann (5) for their article in Endocrinology and Metabolism, published in 1922. It shows the ways in and the ways out, and the different organs which participate in maintaining the blood sugar at an average normal level. This chart, however, requires a little modification now to express what has been learned regarding the action of insulin and epinephrin.

METABOLISM OF CARBOHYDRATE.

There are three ways in which sugar of the blood may be disposed of normally. It may be oxidized at once to yield physiological energy and heat; it may be converted to glycogen for temporary storage—a checking account in the bank; or it may be converted to fat—a savings account or permanent investment. The chief tissue for oxidation is muscle, although practically every other tissue, so far as they have been studied, can also oxidize sugar. This universal capacity to burn this foodstuff has lead some authors, rather hastily as it seems to me, to conclude that sugar is the only fuel of life. This conception received great encouragement a few years ago by the development of the so-called Hill-Meyerhof theory of muscular contraction and recovery. Hill (6) found that when a frog's muscle contracts in oxygen it gives off a little heat during the contraction phase, but gives off much more during recovery after the contraction and relaxation have passed. When the muscle contracts in nitrogen, only the first or "initial" heat is produced, the delayed or recovery heat is wholly lacking. It happens that this fits in perfectly with observations previously made by Fletcher and Hopkins that when a muscle contracts it produces lactic acid, the lactic acid disappearing rapidly if oxygen is supplied, but not disappearing if the muscle is bathed by nitrogen gas. Hill inferred that it was the cleavage of some carbohydrate into lactic acid which produced the initial heat and the oxidation of lactic acid which produced the heat of recovery. Meyerhof (7) working on the same subject by biochemical methods came to the conclusion that the only carbohydrate which can fit the requirements is glycogen, which is a normal constituent of all muscle. He agreed with Hill that the cleavage produces lactic acid, and in fact that the yield of heat which Hill found is just the theoretical heat which should appear when glycogen is broken down to lactic acid, plus the amount used in deionizing the protein combined in solution with alkali and making of it a lactate salt. Meyerhof's equation for the process was as follows:

$$5/n\ (C_6H_{10}O_5) + 5H_2O \rightarrow 5C_6H_{12}O_6 \rightarrow 1C_6H_{12}O_6 + 8\ C_3H_6O_3 \text{ (naerobic phase)}$$

$$1C_6H_{12}O_6 + 8C_3H_6O_3 + 6\ O_2 \rightarrow 6\ CO_2 + 6H_2O + 4C_6H_{12}O_6 \rightarrow 6CO_2 + 10H_2O + 4/n\ (C_6H_{10}O_5). \quad R.\ Q. = 1.0 \text{ (oxidative phase)}$$

The second part—the oxidative phase—describes what happens when plenty of oxygen is present. You will observe that we start with 5 molecules of glycogen and end up with 4. Differently expressed, we start with 30 carbons as glycogen and at the end of the first reaction we have 30, 6 of them as glucose and 24 as lactic acid. In the second reaction the glucose gets oxidized and the 24 carbons of lactic acid (8 molecules) get resynthesized again to glycogen. In Meyerhof's conception the oxidation of lactic acid is for the purpose of restoring the potential energy of glycogen just as if a spring were being wound up or, still better, as if a battery were being recharged ready to deliver its energy again when the switch is thrown, i. e., when the muscle gets a stimulus from a nerve. In his original statement Meyerhof implied clearly that only carbohydrate could be oxidized to furnish the energy for synthesis. Later he disclaimed any intention of excluding fat as a source of this energy.

However, this beautiful conception has in the last six years been considerably defaced. You will observe that the star performer in that view is lactic acid. What Hill (8) calls the "revolution in muscle physiology" which broke out on the last day of 1926, brings forward an entirely new star performer which is called "phosphagen," a compound of creatin and phosphoric acid. It turns out on Hill's own confession that he and Meyerhoff had compromised a small error in their results for the sake of the major conception and in the hope that future work would clear up the discrepancy. The Eggletons (9) in England described phosphagen and almost simultaneously Fiske and Subarrow (10) at Harvard described the same compound as phosphocreatine, showing that it is a very labile substance yielding equivalent proportions of creatine and phosphoric. The Eggletons showed further that this substance is broken down when muscle contracts and disappears again when oxygen is admitted. Hill's own work with Hartree had revealed that there is a small amount of the delayed heat not accounted for by the oxidation of lactic acid and Embden and co-workers proved that some lactic acid appears after contraction is over. These facts did not fit into the nicely balanced thermodynamic equation of Hill and Meyerhof. There were several other facts which we shall not have time to enumerate that were not easily reconciled with the theory. The final blow came, however, with the accidental discovery by Lunds-

gaard (11) at Copenhagen in 1930 that muscle poisoned with iodoacetic acid contracts without producing any lactic acid. This has now been fully confirmed many times and the new theory, which must take Lundsgaard's name, includes phosphagen as follows: When a muscle contracts phosphagen breaks down into creatine and phosphoric acid. Fischer and Meyerhof (12) and Lundsgaard (13) independently have shown that this furnishes the energy for contraction. The energy for resynthesizing the phosphagen in turn comes in part from the cleavage of glycogen to lactic acid, which explains why lactic acid appears after contraction, and the energy for rebuilding the glycogen comes from combustion of *lactic acid or glucose*, or, as many now believe, from fat if carbohydrate is not present in sufficient quantity. Thus we see how carbohydrate is disposed of in muscular work. Every contraction, however small, takes place by the release of potential energy from a complex compound when it suddenly explodes, so to speak, into smaller fragments. But the mechanism is automatic. No sooner is this compound exploded, than the fragments are gathered together and resynthesized in part, by expenditure of energy from another explosion—this time of glycogen, a complex carbohydrate. The second explosion is unexploded, if I may coin the word, by combustion of other carbohydrate and lactic acid, a degenerate form of sugar, becomes ennobled, so to speak, as it continuously returns to the higher form. Lohmann (14) recently has shown that the formation of lactic acid from glycogen in dialyzed muscle extract requires the action of a co-ferment system consisting of inorganic phosphate, adenyl-pyrophosphate and magnesium. Presumably this system is operative also in the live muscle.

Lactic acid, we know now, can be formed in all kinds of tissues, which leads us to suppose that much the same mechanism for release of energy exists in all. But it does not appear in more than trifling amounts *unless oxygen is lacking*. Any form of asphyxia whether local or general always reveals it in larger amount. When a muscle works faster than the physiological rate, which means faster than oxygen can be supplied to resynthesize the lactic acid, it becomes fatigued, as we all know. Washing away or oxidizing away the lactic acid relieves fatigue.

THE RESPIRATORY QUOTIENT.

Dr. Carpenter has already explained to you what the respiratory quotient signifies. This relationship of the volume of CO_2 eliminated to the volume of O_2 absorbed varies ordinarily only between about 0.73 to 1.00. The lower figure means combustion of nearly pure fat, the higher of nearly pure carbohydrate. These facts follow from the following simple equations:

Tripalmitine is $C_3H_5\ (C_{16}H_{31}O_2)_3$ or

$$C_{51}H_{98}O_6 + 72.5\ O_2 = 51\ CO_2 + 49\ H_2O$$

$$\frac{51\ CO_2}{72.5\ O_2} = 0.703$$

Glucose

$$C_6H_{12}O_6 + 6\ O_2 = 6\ CO_2 + 6\ H_2O.\ \text{Hence}\ \frac{6\ CO_2}{6\ O_2} = 1.0.$$

It is relatively simple to obtain respiratory quotients on the entire body, and Dr. Carpenter has explained to you the method. Having found the non-protein R. Q., then, for any quotient intermediate between 0.707 and 1.0 we can by a relatively simple calculation find the percentage of the total oxygen taken up by the oxidation of each of the two non-nitrogenous food stuffs. Thus $100\ \frac{\text{R. Q.} - 0.707}{0.293}$ gives the percentage of carbohydrate oxygen; $100\ \frac{1.00 - \text{R. Q.}}{0.293}$ gives the percentage of oxygen for fat.

If we eat large amounts of carbohydrate we are sure to obtain R. Q.'s close to 1.0 and if we continue on such diets for a few days we get R. Q.'s higher than 1.0, which mean that carbohydrate is being converted to fat, thus:

$$\underset{\text{glucose}}{4\ C_6H_{12}O_6} + O_2 = \underset{\text{palmitic acid}}{C_{16}H_{32}O_2} + 8\ CO_2 + 8H_2O.\ \frac{8\ CO_2}{1\ O_2} = 8.0\ \text{R.Q.}$$

The R. Q. of this reaction would be 8.0, but of course only a little carbohydrate can be converted to fat at a time, and the consequence is a little of this reaction would be mixed with much of the ordinary metabolism with a quotient say of 0.90.

Suppose 2 per cent of the metabolism represented a R. Q. of 8.0 and 98 per cent represented an R. Q. of 0.90, and suppose the total oxygen absorbed was 10 L. Taking 0.2L of O_2 at an R. Q. of 8.0 the CO_2 would be 1.6 L, and the total CO_2 would be 8.82 + 1.6 = 10.42. Since the O_2 we have supposed is 10 L, the total R. Q. would be 1.04. The highest R. Q.'s ever obtained were about 1.5–1.6 which at the same rate of O_2 absorption we have imagined would mean the use of approximately 10 per cent of the oxygen for the conversion to fat, with a R. Q. of 8.0 and 90 per cent for ordinary metabolism with the R. Q. of 0.90.

The inverse relationship holds if we have conversion of fat to carbohydrate. This is a hotly controverted question at present and we shall encounter some new evidence in the latter part of this lecture. Suppose palmatic acid were converted over to glucose by Bleibtrau's reaction, what would be the R. Q.?

$$3\ (C_{16}H_{32}O_2) + 21\ O_2 = 8\ (C_6H_{12}O_6)$$

There is no R. Q. of this reaction because no CO_2 is produced. What the effect on the total R. Q. would be could only be determined by knowing how much sugar was being formed. Let us suppose that we could demonstrate the production of 10 gm. sugar in a period in which 8 L of CO_2 were being eliminated and the basal R. Q. was 0.8, i. e., 10 L of O_2 were absorbed. Imposing the special conditions which produce 10 grams sugar the extra oxygen necessary is found by the proportion

$$\begin{array}{llll} 8\ (C_6H_{12}O_6) & : 21\ O_2 & : : 10\ \text{gm.} & : x \\ \quad 1440 & : 672 & : : 10\ \text{gm.} & : 4.66\ \text{gm.} \end{array}$$

This gives the O_2 in grams. Multiplying by 0.7 (actually 0.6998) we get 3.26 liters. Adding this to 10 gives 13.26 liters and dividing into 8 L CO_2 we arrive at the R. Q. 0.60. Properly obtained quotients in this neighborhood can mean nothing else than the formation in metabolism of oxygen-rich substances (carbohydrates) from oxygen-poor substances (fats).

REGULATION OF CARBOHYDRATE METABOLISM.

In 1889 Minkowski working at Kônigsberg in East Prussia, observed that a dog whose pancreas had been removed excreted large amounts of sugar. This was the first step toward solution of the extremely important medical problem of diabetes mellitus. There had been many indications that the pancreas, if not the actual site of the disease, at least was involved. For example,

autopsies frequently had revealed that the pancreas was very much shrunken in the last stages of diabetes. There had also been indications of degenerative processes visible under the microscope. Minkowski himself undertook to demonstrate that the pancreas contains an extractable substance which can take the place of the pancreas itself in the regulation of carbohydrate metabolism, for it was just at this time, as Minkowski was continuing his work on pancreatectomy and its effects on metabolism, that Murray in England was demonstrating that an extract of thyroid gland can replace the gland itself in restoring a myxodematous person to normal. Minkowski did not succeed in this attempt for reasons which now are perfectly clear. But he did formulate perfectly definite ideas as to the role played by the pancreas in carbohydrate metabolism. He stated that the reason sugar appears in the urine when the pancreas is removed or when seriously diseased, is that sugar cannot be oxidized. Something produced by the pancreas participates in the oxidation of sugar. When that substance is lacking, oxidation fails, sugar piles up in the blood, and leaks out through the kidney. The name "hormone" for such a material had not yet been invented, but of course now we apply the term hormone to such a product continuously formed by an organ, and delivered directly to the blood stream.

Several observers have now demonstrated that the general seat of the metabolic action of insulin, so far as combustion is concerned, is in the muscles. Taking blood from the arteries supplying the muscles and from the vein draining the blood away, before and after introducing insulin, shows clearly that the difference in sugar concentration between these two bloods increases when insulin reaches the muscle. A second important action, probably not less important than the combusion of sugar, is its prompt conversion to glycogen when excess exists in the blood. This process also is facilitated by the presence of insulin as has been demonstrated clearly by Cori and Cori (15).

As early as 1907 it was surmised by Zuelzer that the internal secretion of the pancreas, which regulates sugar metabolism, is antagonized by epinephrin, the secretion of the adrenal gland. Zuelzer (16) actually had a pancreas preparation which would diminish the excretion of sugar of a diabetic dog and would lower the blood sugar previously raised by the injection of epinephrin. This antagonism between insulin and epinephrin is now well established. When epinephrin is injected into a

normal animal the blood sugar rises because glycogen in the liver is converted into glucose rapidly and passes out into the blood stream. Epinephrin even reduces the combustion of sugar (17). When insulin is given exactly the opposite effects are seen. Blood sugar is reduced by two methods, combustion in the muscles and storage of glycogen particularly in the liver. It has been suggested that an excess production of epinephrin, even though small in amount, continuing over a period of years, might possibly be the cause of diabetes mellitus. Insulin, according to this idea, would be continuously suppressed in its action and eventually stopped altogether. Epinephrin would account for the high blood sugar and the inability of the diabetic organism to oxidize sugar or to form glycogen. This remains only a working hypothesis.

A rival theory to that of Minkowski, originally conceived by vanNoorden in Vienna, is that in the absence of the pancreatic hormone, sugar is produced in excessive quantity by the liver and piles up in the blood, not because it cannot be burned, but merely because more is produced than is required in the muscles and elsewhere. Insulin then would have as its primary function the inhibition of sugar formation. This so-called over-production theory has some few facts in its favor. But the discovery of insulin has tended to confirm Minkowski's idea that the primary function of insulin is oxidation rather than the suppression of sugar formation.

For example, a dog made completely diabetic by extirpation of the pancreas has an R. Q. close to the theoretical for the combustion of fat, namely, 0.7. Quite frequently the quotient falls somewhat below this, indicating, according to one interpretation that fat is being converted to sugar and according to another interpretation that fat is only partially oxidized, the products instead of being excreted through the lung being excreted through the kidney. These products are the so-called acetone bodies, diacetic acid, acetone itself and β-hydroxybutyric acid. I shall not have time to go into the chemistry of these ketones, so called, but will indicate merely that if these partially oxidized products are formed in large quantity, there is no doubt that the result would be a depression of the R. Q. Magnus-Levy has concluded that a normal subject producing 40 grams of Beta-hydroxybutyric acid would have an R. Q. in the neighborhood of 0.68. Giving insulin invariably increases the respiratory quotient, provided glucose is available.

GLUCONEOGENESIS.

I shall devote the remainder of my time to a discussion of the processes described by this term, which means the new formation of sugar from either protein or fat. The term was introduced by the vanNoorden school to account for the excess production of sugar from other than carbohydrate sources. It has been revived and discussed energetically by Macleod and his pupils at Toronto and latterly at Aberdeen. There are three main lines of investigation of this subject: (1) The D:N ratio in the urine of diabetic subjects; (2) Perfusion experiments, chiefly perfusions of the liver; (3) Respiratory metabolism.

The D:N ratio is the relationship of dextrose in the urine of a diabetic animal to the nitrogen excreted. The argument as regards the new formation of sugar will appear in a moment. We have three well studied types of diabetes: (1) the human subject, seriously ill because of degeneration of the pancreas; (2) the animal, chiefly the dog, after removal of the pancreas; and (3) the animal poisoned with the glucoside phlorhizin. In all three of these types of diabetes sugar which cannot be oxidized appears in the urine. When there is no carbohydrate whatsoever in the food the carbohydrate of the body itself is quickly exhausted and nevertheless sugar continues to be excreted. Obviously it must come from some other source than carbohydrate. Now if the excess sugar bears a definite ratio to the nitrogen of the urine, since nitrogen can come only from the protein, it will be safe to infer that the sugar also comes only from the protein. The facts are that the D:N ratio is a reasonably fixed quantity in the phlorhizinized animal, as Graham Lusk was the first to prove definitely. Lusk's ratio, 3.65 to 1, has become a pilot light in the study of diabetes. It means that a dog, under the influence of phlorhizin for about three days, fed meat or meat and fat, will continue to produce sugar in relation to N of the urine in such a proportion that 100 grams of protein is forming approximately 58 grams of sugar. Incidentally, this fact illustrates the extreme difficulty in which the totally diabetic person found himself before the discovery of insulin. He lost through the urine all of the carbohydrate eaten, nearly 60 per cent of his protein, and could very imperfectly metabolize fat. In the depancreatized dog the average D:N ratio beginning about two days after the pancreas was removed, and continuing as long as the dog could

eat a meat or meat and fat diet was, as Minkowski found, about 2.8 to 1. This ratio ever since has been called the Minkowski ratio. It means that approximately 44.8 grams of sugar can come from 100 grams of protein in the depancreatized dog. In our experience, however, the Minkowski ratio is much more difficult to establish than is Lusk's ratio on the phlorhizinized dog. After all, it is only an average ratio of some nine dogs as studied in Minkowski's laboratory and fed exclusively on meat. Ratios ranging between 2.6 and 1.0 are not at all uncommon, when the appetite fails, as frequently happens in the later stages of insulin deficiency. However, the interesting point in this particular connection is that the ratio under meat feeding rarely goes higher than, say, 3.0.

In human diabetes one is met by the difficulty that the patient is not always reliable. You can not control your experiment so well as you can with an animal. You cannot lock up a diabetic patient in a cage and have the cage locked in a room and see that the patient gets only certain items of food and that no urine is lost. As a consequence, ratios have been much more variable in human diabetes than in animal experimentation.

If all of the carbon of protein were converted to sugar, the D:N ratio would lie from 6.4 to 6.7, depending upon the exact composition of the protein fed. To prove beyond a doubt the conversion of fat to carbohydrate, it is conceded by the believers in gluconeogenesis from fat that the ratio must be higher than 6.7 to 1. Such ratios have been reliably reported in clinical studies of human diabetes, but it must be said that in the most carefully controlled work, as, for example, in Woodyatt's laboratory in Chicago, in Wilder's laboratory at the Mayo Clinic and in Joslin's laboratory in Boston, such ratios are very infrequently found. Likewise ratios of this order are never found in properly controlled work on diabetic animals. Therefore the evidence from the study of the D:N ratio is that sugar cannot be formed from fat. The fundamental economy underlying this fact seems to be the following: Nature is a better banker than man. Whenever we have an income of energy greater than our expense requirements, the balance is put into savings. Normally we have a checking account which we call glycogen and we have a more permanent savings account which we call fat. Now it is obviously in the interest of good physiological economy, as it is in the interest of good

financial economy, to conserve the more fixed savings. It should be, and it is easier to convert a favorable balance into savings than to convert permanent savings back into small change for current expense account. In primitive man this physiological principle had survival value, for when food was abundant the surplus energy could be stored away in his body as fat and could be drawn upon with difficulty only, inducing him thereby to seek other sources of food before the reserve had been exhausted. This principle is by no means so important for modern man with food everywhere abundant. It is rather an embarrassment because we find it all too easy to put food into the reserve account and all too difficult to take it out again.

The second line of evidence in this study of gluconeogenesis comes from the perfusion of the liver. This is a very common type of physiological experiment. Much information has been gained regarding the intermediary stages of the metabolism of protein and carbohydrate and to a less extent of fat by setting up an apparatus by which defibrinated blood can be pumped through the blood vessels of the liver over and over again, the liver meantime being kept at body temperature in a water bath and as nearly normal as we can imitate normal conditions outside the body. For example, it was long ago discovered that lactic acid in the perfused liver could be converted to sugar and also to glycogen. This supplements the fundamental muscle physiology which we were discussing a while ago. Also, it was learned by perfusion of the liver that the amino acids can form sugar. In recent years this type of experiment has been used in the attempt to show that fats passed through the liver will yield sugar. One such set of experiments performed in Dale's laboratory in London, purported to show that when ordinary defibrinated blood was passed through the liver of a dog or cat whose liver glycogen had been reduced to a minimum by feeding the animal for several weeks on a high fat diet, more sugar came out of the liver than could be accounted for by the small amount of glycogen remaining or by the protein metabolism of the liver. The inference was that the excess sugar was coming from fat. These experiments published by Burn and Marks (18) were repeated in our laboratory by Dr. Gregg (19) with more careful attention to several details than Burn and Marks had applied to the experiments. For example, Burn and Marks claimed that the dis-

tribution of glycogen remaining in such a liver was perfectly uniform from lobe to lobe. Gregg found that this was not the case. Secondly, they overlooked the fact that much of the reducing substance of the blood is not sugar at all, but is uric acid, creatinine, glutathione, ergothionine, etc. In other words, they failed to determine the true or fermentable sugar. Gregg supplied this defect and he found that the true sugar coming from the liver not only did not increase, but actually decreased in a considerable majority of his experiments. It was necessary, Gregg found, to set up real carbohydrate and fat balances from the beginning to the end of the experiment. Such balances are illustrated in the accompanying table (Table I).

TABLE I.

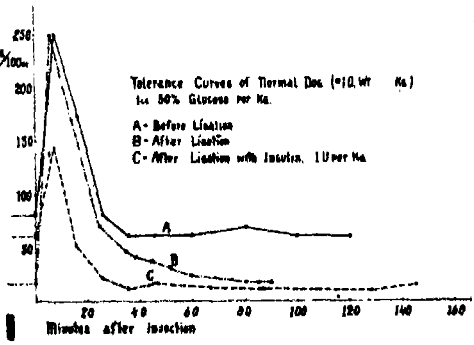
CARBOHYDRATE AND FAT BALANCE IN LIVER PERFUSION.

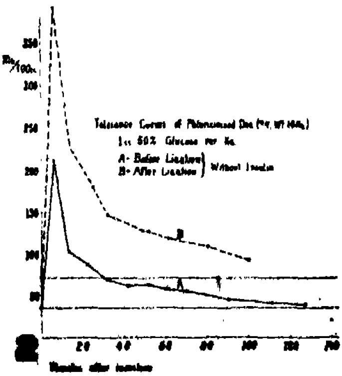
TOTAL WEIGHTS	BEGINNING		END	
	Carboh. gm.	Lipids gm.	Carboh. gm.	Lipids gm.
Blood sugar	0.644		0.568	
Blood sugar removed			0.246	
Free sugar	0.206		0.050	
Glycogen as free sugar	0.330		0.183	
Liver lipids		4.740		3.670
Blood lipids		0.567		0.400
Blood lipids removed				0.189
Total grams	1.180	5.307	1.047	4.259

More recently Jost (20) has claimed that perfusion of the liver with phospholipids yields sugar which can only be accounted for on the assumption that these phospholipids are converted over to carbohydrate. I have no means of judging the accuracy of this work. However, some other experiments reported from Best's laboratory in Toronto, which claim to prove that lecithin fed to diabetic animals causes the production of extra sugar in the urine, have been checked in our laboratory in a few experiments and have been found incorrect. When carefully purified lecithin is fed to a diabetic animal, it does not affect the D:N ratio or the R. Q. It is quite possible that this type of experiment will eventually furnish convincing evidence that sugar may be produced from fat. In our laboratory Dr. Eaton and I have found that a fraction of the fat extractable from the

pancreas and belonging to the cerebrosides (or possibly sphyngomyeline), depresses the R. Q. and increases the D:N ratio of depancreatized dogs (21).

The change in sugar tolerance when an animal is made diabetic with phlorhizin is shown in Charts 1 and 2, taken from a recent publication on this subject from the Rochester laboratory (4). When a certain definite doze of glucose was injected into a vein of a normal dog and a sample of blood drawn from another vein at frequent intervals, "tolerance curves" like those in Chart 1 were obtained. These could be repeated at three-hour intervals. When insulin was given with the glucose a lower curve (higher tolerance) was obtained (curve C). In the phlorhizinized dog (Chart 2) the tolerance





curve from the same dose of glucose per kilogram of body weight gave a lower curve (A). This does not indicate higher tolerance; it only shows that some of the sugar passed out through the kidney. When the kidney blood vessels were ligated so that no sugar could escape from the blood to the urine, the dose of glucose produced a much higher curve. The lower tolerance of the diabetic organism is shown by the difference between this curve and a similar test (after ligation of the vessels) in the normal dog (Chart 1). The lower tolerance of the phlorhizinized dog is shown especially by the prolongation of curves A and B in Chart 2 and is due probably to injury to vessels of the liver, similar to the injury produced in the kidney.

The study of the respiratory metabolism of diabetic animals has in the main confirmed the study of D:N ratios. The verdict to date has been that there is no diminution of the R. Q. to the point where one could safely infer that sugar is being

formed from fat. I know of only a few experiments, including one from Boothby's laboratory, which furnished R. Q.'s too low to be accounted for on any other hypothesis. Wilder, Boothby and Beeler (22) were studying quite exhaustively a single case, and they were testing out the specific dynamic action of high fat meals on the diabetic subject. In a few instances they obtained quotients immediately following the meal as low as 0.62 or 0.61. The quotients gradually rose from that level to the level prevailing before the meal, namely, about 0.69. Boothby did not comment on the significance of this quotient in reporting the work. Likewise in Joslin's laboratory in a few cases out of a large number which he studied following meals containing a considerable amount of fat, quotients as low as 0.57, 0.58 and 0.62 were found. Joslin believed these quotients were really significant of gluconeogenesis from fat. Magnus-Levy has stated that in diabetes a quotient as low as 0.65 cannot be explained in any other way and he says a quotient of 0.60 would prove it beyond peradventure. But such a quotient would be obtained in the diabetic only if in the metabolism of 200 grams of protein and 250 grams of fat 350 grams of sugar were formed besides 40 grams of Beta-hydroxybutyric acid.

The main difficulty which stands in the way of getting crucial evidence concerning the conversion of fat to carbohydrate by the R. Q. method is that, if combustion of carbohydrate keeps up with its formation, there is no lowering of the R. Q. For example, if the palmitic acid should be converted to glucose with an R. Q. of 0.60, as described above (page 342), and should then be immediately burned with an R. Q. of 1.0 the quotient obtained would be somewhere between these two values and the low R. Q. would entirely disappear. It occurred to us that the fatty seeds during germination, where low R. Q.'s have frequently been reported and have been interpreted to mean that the fat is being converted to sugar for later conversion to cellulose or combustion would be suitable objects in which to separate the two processes: (1) conversion of the fat to carbohydrate and (2) the combustion of the carbohydrate. The castor bean was chosen and its respiratory metabolism at various stages during germination was studied in the so-called Warburg respirometer (23). It was soon found in confirmation of earlier work on this seed, that after the first few hours of germination low R. Q.'s are regularly obtained.

The table shows some of these quotients obtained on individual beans (Table II). It will be observed that the level of the quotients depends to some extent upon the stage of growth reached. The next question was to study on the whole young plant separated from the endosperm of the seed and to compare its respiratory metabolism with that of the whole germinating bean. The next table shows that the bean as a whole gives as usual its low R. Q., but that when the cotyledons are separated out of the bean and together with the hypocotyl or radicle are

TABLE II.

CASTOR BEAN EXPERIMENTS.

Single Bean in Warburg App.
Variation with Stage.

Bean No.	Stage of growth L. of hypocotyl mm.	Length of exper. min.	RESP. EXCH.		R. Q.
			CO_2 cu. mm.	O_2 cu. mm.	
13..........	12	69.0	234.9	345.6	0.679
14..........	12+	46.5	155.8	231.4	0.535
17 (1).......	16	30.0	208.2	337.8	0.617
18 (2).......	16	32.0	211.4	407.8	0.518
16 (1).......	19	32.0	142.6	247.6	0.576
16 (2).......	19	32.0	130.0	223.3	0.582
					Av.0.585
18..........	20	15.0	83.4	252.9	0.337
12 (1).......	23	34.5	117.3	406.3	0.289
12 (2).......	23	23.0	107.8	287.4	0.373
12 (3).......	23	22.5	98.0	320.4	0.306
10..........	24	31.5	146.7	413.8	0.355
11..........	29	32.5	127.9	496.9	0.257
19..........	32	41.0	160.6	420.9	0.382
20..........	33	37.5	184.0	481.2	0.382
			Av.20-33 mm		0.323

studied in the respirometer, quotients approaching those for combustion of carbohydrate alone are obtained. (Table III.) Comparing now the respiratory metabolism of the endosperm by itself with that of the whole bean, we find that its R. Q. instead of being slightly lower as we expected, is slightly higher. This is probably due to the fact that it is necessary to strip off the seed coat and thereby to expose the endosperm tissue more completely to the outside air, and this results in combustion of some of the already formed carbohydrate. Comparing these two, however, with that of the whole plant, we

find the same contrast as before. Finally, we studied the respiratory metabolism of a considerable number of beans by confining them for several days in a glass bottle and analyzing the air contained in the bottle at the termination of this period. From such studies we learned that the low R. Q.'s prevail not merely over the few minutes necessary to obtain the R. Q. on the individual seed, but throughout the entire germination period. We have here then a demonstration that the two processes can be studied separately— the conversion of fat to sugar producing a low quotient, and the young plant then oxidizing a portion of this sugar and giving a high quotient.

TABLE III.

RESPIRATORY EXCHANGE OF WHOLE BEAN, ENDOSPERM AND NEW PLANT.

No.	Part	Stage	Length of exper., min.	CO_2 cu. mm.	O_2 cu. mm.	R. Q.
32	Whole bean	40 mm., 1 branch	59.5	236.2	612.2	0.386
32	Endosperm	40 mm., 1 branch	52.0	195.9	426.8	0.459
32	New plant	40 mm., 1 branch	72.0	155.8	140.8	1.106
33	Whole bean	45mm., 4 branches	57.0	292.9	604.5	0.484
33	Endosperm	45mm., 4 branches	44.5	184.0	331.7	0.555
33	New plant	45mm., 4 branches	70.0	173.3	192.5	0.90

The conversion of fat to carbohydrate in these beans has been confirmed by two other methods. Chemical analyses which Dr. H. B. Pierce has carried out in our laboratory demonstrate that the percentage of fat steadily falls from the time germination begins to the end, that the percentage of protein scarcely changes at all, but that the percentage of sugar identified as cane sugar, increases, as does also the percentage of crude fiber or cellulose. The other method consists of burning the entire bean at different stages in a modified oxy-calorimeter. This instrument was devised by Benedict and Fox at Boston for the purpose of studying the heat value of mixtures of foodstuffs when burned in pure oxygen. This was modified sufficiently to collect and weigh the CO_2 formed, to keep the temperature down by cooling the air, and by using a more accurate spirometer so as to measure the oxygen consumed. Dr. Daggs in our laboratory has used this apparatus to burn the ungerminated bean and the bean germinating at several distinct stages up to a total length of the hypocotyl of about

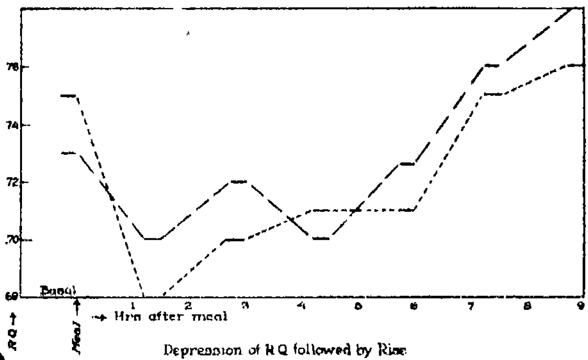
3 inches. The R. Q. increases steadily from the ungerminated stage up to the last stage studied (24).

We have thus obtained a complete demonstration of the conversion of fat to carbohydrate and the partial oxidation of the carbohydrate with the characteristic effects on the respiratory metabolism.

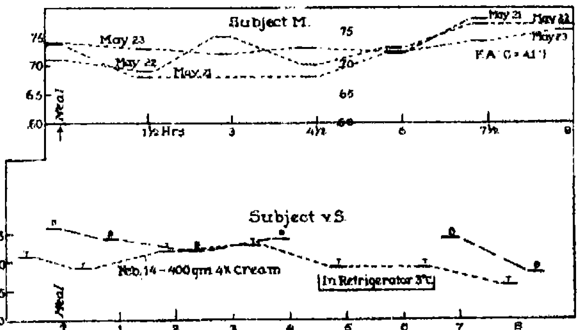
With Drs. Estelle E. Hawley and Carroll M. Johnston (25) we have studied the problem in human subjects. It happened that one of them had an unusually high tolerance for fat. It occurred to us that in such an individual by prolonging a tolerably high fat diet we might deprive him of glycogen sufficiently so that when he was given a large meal of butterfat, selected because it is already emulsified in the form of cream, and therefore quickly digested, the earlier quotients after the meal would show a considerable depression of the quotient, signifying conversion of some of the fat to sugar and its storage as glycogen. Later this glycogen would be mobilized and burned and as a consequence the R. Q. would rise. This hypothesis was predicated on two other demonstrated facts: (1) That at best it is difficult to convert fat to carbohydrate, and (2) that the demand for glycogen as tissue reserve at times dominates the demand for sugar as fuel. Hence to exhibit the conversion it would be necessary to establish these special conditions: (1) Just that degree of tissue hunger for glycogen which would cause retention of any sugar formed; (2) that there should be no other adequate source of sugar available, and (3) that the subject at the moment of test would be already accustomed to digesting and absorbing large amounts of fat. With these conditions rightly adjusted, the hypothesis was that a certain sequence of R. Q.'s would be obtained that could not be plausibly explained in any other way. The low quotient immediately following a high fat meal when averaged with the high quotient later in the day, would produce a quotient which would stand near the accepted level for combustion of the ingested fat.

Dr. Gregg, in our laboratory, had calculated that the theoretical quotients for butter fat should be 0.72, instead of the usually accepted 0.707 for mixed food or body fats, the higher level being explained by the presence of lower fatty acids in butter which give higher quotients than the usual food fats. Encouragement was obtained from the earlier experiments on this subject and then other subjects, to a total number,

of seven, were studied on the same high fat diet. The last diet consisted exclusively of 4X cream, actually 37½ per cent fat by analysis. Only this diet of cream gave the best results (from our point of view. The charts 3 and 4 show that the predicted sequence of quotients could be obtained in single experiments or as an average of several experiments on the same subject or several experiments on different subjects. They are best



3 Depression of RQ followed by Rise
.... Average of 7 "Early" Experiments
— — — Average of 3 Experiments on Subject M



4 Effect of Cold on R.Q. after High-Fat Meal
B Benedict Method T Tissot Method

obtained, however, while the subject is still somewhat unaccustomed to the high fat diet. This was not anticipated. The phenomenon of adaptation or improved tolerance to high fat diet has only been observed so far as we are aware by Wigglesworth (26), who observed it in rats. It shows up clearly at several points in our experiments.

The best results, from the standpoint of the hypothesis, were obtained before this improved tolerance had asserted itself. One of the charts shows the improving tolerance in

three successive days on the same subject (M). We call attention to the fact also that sometimes these low quotients continue throughout the day, more especially in subject H, who had a very low tolerance for fat, both in the sense of being unable to oxidize the fat successfully and in the sense of showing the highest ketosis of any of the subjects. In the attempt to explain these low R. Q.'s we have calculated the theoretical depression of the quotient which might conceivably be produced by conversion of protein to sugar. The method involves a rather long calculation which I shall not have time to give in detail. It is a well-established method first introduced by Magnus-Levy and used subsequently by Lusk, Geelmuyden, Macleod, and others. In our experiment if we assume that 58 per cent of the protein metabolized were converted to sugar and stored as glycogen, there would be as a maximum a reduction of the quotient, amounting to 0.025. Secondly, we have undertaken to determine how much the quotient might be lowered by conversion of the glycerol of fat to sugar. It is well known that in the diabetic organism when glycerol is fed, extra sugar appears in the urine equivalent to the amount of sugar which can be formed if all of the carbon of the glycerol were converted to glucose. Making this calculation in our experiments we found that if all the glycerol of the fat meal were converted to sugar, and stored as glycogen, the quotient might be depressed as much as 0.03 and we have some experiments in which the theoretical amount of glycerol was fed on one of the days adjacent to the all cream diet. There was at times a similar drop in R. Q.'s immediately after the meal following glycerol as following the high fat, which would lead one to think that on the day of high fat ingestion all of the glycerol separated from the fatty acids and was converted to glycogen. It is perfectly easy to imagine that this happens when nothing but glycerol is fed, but the total amount of glycerol of the fat cannot possibly be separated from the fatty acid after absorption into the circulation unless the fatty acids at the same time were metabolized. Hence we are limited in calculating the glycerol available for conversion to sugar and thence to glycogen to that amount which corresponds to the highest fat metabolism of the hour when the R. Q. was determined. The highest fat metabolism in a single hour in any of these experiments was 10 grams of the butter fat. The glycerol is roughly one-tenth of this, or one gram. Conversion

of one gram of glycerol to glucose would not lower the quotient more than 0.003.

Next we attempted to correlate the R. Q.'s with the ketosis developed in these subjects. The acetone bodies were determined in the blood and also in the urine. If the ketosis were responsible for the low R. Q.'s as Shaffer has demonstrated should be the case from his *in vitro* work, the quotients should be lowest when the ketosis is highest, and *vice versa*. Our series show, however, that this is not the case whether we consider the total acetone of the blood or of the urine. Finally, we have calculated what would be the effect on the R. Q. from the increase in the ketone bodies in the blood from one period to the next.

It is necessary also to make allowance for the increased ammonia production which results from the acidosis. Making these calculations in several of our typical experiments, we found that the only effect is a lowering of the quotient of not more than 0.01. Now if we imagine that all of these various influences known to have the effect of lowering the R. Q. were operative at once, which in itself is very improbable, we might have a total effect of about 0.04. In other words, a quotient which would be about 0.73, if the fat were oxidized completely as fast as it was absorbed, would be depressed by these several factors to a level not lower than about 0.69. This is the familiar R. Q. of total diabetes.

In this work we have literally scores of quotients lower than this. A considerable number in the neighborhood of 0.60 to 0.65, still more from 0.65 to 0.69. As we have said before, these quotients below 0.69 occur most frequently in the person with a low tolerance or in the very early experiments on other subjects which had a normal or high tolerance for fat.

There is one other possible explanation of low quotients which should be considered before we infer that we have demonstrated in these experiments the formation of sugar from fat. You will remember that the most plausible theory for the oxidation of fatty chains in the body is Knoop's theory of Beta-oxidation. Suppose we have a fatty acid like oleic acid with 18 carbons, and with a double bond between the 9th and 10th carbon. It is assumed that the chain first breaks at this weak point in the double bond and two chains of 9 carbons each are obtained which may be oxidized at either end. Now, if we try to imagine an orderly process of Beta-oxidation, that is, splitting off of two carbons at a time with subsequent formation of CO_2

and water by way of several intermediary products, it is clearly possible that the absorption of oxygen may considerably outrun the formation of CO_2. We believe it is necessary to rule out this possibility before concluding that in the human subject, on a high cream diet, the conversion of fat to carbohydrate has been demonstrated. Furthermore, it will be necessary to find the carbohydrate.

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Frontiers of Medicine.

One of the Century of Progress Series, this book delves much farther back into history than the last century for its background. With deft sure strokes the history of medicine is drawn, a picture which merges into the dynamic medical frontiers of today, where disease and the threat of disease are attacked on innumerable specialized sectors. The middle chapters give the impression of being hurriedly written, but the final chapters round out to an excellent discussion of present achievements and future possibilities.—L. H. S.

Frontiers of Medicine, by Morris Fishbein. x+207 pp. Baltimore, the Williams and Wilkins Co. 1933.

Telling the World.

Perhaps nothing in this "Century of Progress" has been more striking than the development of communication. Telegraph, telephone, wireless, radio—the story of all of these is unfolded graphically by the former Chief Signal Officer of the U. S. Army. The opportunity is embraced to familiarize the reader with the part played by the Signal Corps in the advances in this great field. A new terminology is developed and defined. The Century of Progress Series appears to be sustaining the high standard set by the earlier volumes.—L. H. S.

Telling the World, by Gen. George O. Squier. xii+163 pp. Baltimore, the Williams and Wilkins Co. 1933.

Fighting the Insects.

This is a most interesting story of the life, experiences, contacts, unusual situations, extensive travels and everyday duties of the author, an outstanding entomologist. Woven into this life story is the history of the development of many phases of economic entomology as they have been seen personally by a big man in a very prominent administrative position. The problems are made real and intensely interesting by the personal experiences and contacts of Dr. Howard as he is fighting the insects through his research workers in the Bureau of Entomology.—D. M. DeLong.

Fighting the Insects, by L. O. Howard. 233 pp. New York, The MacMillan Co. 1933.

FAT METABOLISM

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According to Voit, a man ingests as a part of his food an average of 56 grams of fat per day. Assuming this average to be correct and allowing for a lower consumption during infancy and childhood, we find that when a man reaches the age of forty he will have eaten approximately 700 kg. of fat, the energy value of which is nearly 6½ millions of large calories. This is equivalent to approximately 2.7×10^{16} ergs or 2.6×10^{9} kilogram-meters. It is, however, less than 20% of the total energy intake.

The tissues of an adult human contain relatively constant amounts of protein and carbohydrate. Their fat content, on the other hand, may vary within wide limits depending upon many factors.

Two main classes of fatty substances are found in animal tissues. Under the French classification these have been designated as the 'element variable' which is made up of true fats and oils, chemically glycerides of fatty acids, and the 'element constant,' consisting of such complex compounds as lecithin, cerebrosides, lipo-proteins and the like. The amounts of the former class of compounds found in the tissues vary widely with different individuals; in starvation these compounds are readily mobilized and used as sources of energy. Substances in the latter class occur in relatively constant amounts in tissues; in starvation they resist the forces of mobilization. From a functional standpoint, the latter are undoubtedly far the more important.

The most characteristic part of the lipid (or fat) molecule is its fatty acid. In order to show more clearly the numerous fatty acids which occur in the food, most of which may enter the body tissues if this food is eaten when body fat is being stored, there is grouped in Table I a list of the "food fatty acids."

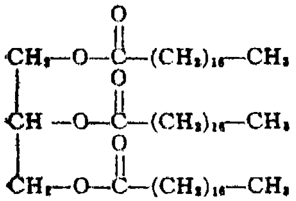
TABLE I.

THE FATTY ACIDS WHICH OCCUR IN FOODS.

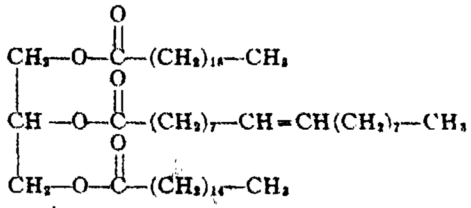
Name of Acid	Formula	No. of HC=CH	Mol. Wt.	Iodine No.	Typical Occurrence in Foods
Butyric	$C_4H_8O_2$	0	88	0	Butter
Caproic	$C_6H_{12}O_2$	0	116	0	Butter
Caprylic	$C_8H_{16}O_2$	0	144	0	Butter, cocoanut oil
Capric	$C_{10}H_{20}O_2$	0	172	0	Butter, cocoanut oil
Lauric	$C_{12}H_{24}O_2$	0	200	0	Butter, cocoanut oil
Myristic	$C_{14}H_{28}O_2$	0	228	0	Butter, nutmeg fat
Tetradecenoic	$C_{14}H_{26}O_2$	1	226	112	Fish oils
Palmitic	$C_{16}H_{32}O_2$	0	256	0	All fats and oils
Hexadecenoic	$C_{16}H_{30}O_2$	1	254	100	Peanut oil, fish oils
Hexadecatrienoic	$C_{16}H_{26}O_2$	3	250	305	Fish oils
Stearic	$C_{18}H_{36}O_2$	0	284	0	Tallow, lard
Oleic	$C_{18}H_{34}O_2$	1	282	90	All fats and oils
Linolic	$C_{18}H_{32}O_2$	2	280	181	Animal lipids, semi-drying oils
Linolenic	$C_{18}H_{30}O_2$	3	278	274	Rarely in foods
Clupanodonic	$C_{18}H_{28}O_2$	4	276	368	Fish oils
Arachidic	$C_{20}H_{40}O_2$	0	312	0	Peanut oil
Gadoleic	$C_{20}H_{38}O_2$	1	310	82	Fish oils
Arachidonic	$C_{20}H_{32}O_2$	4	304	334	Animal lipids, fish oils
Eicosapentenoic	$C_{20}H_{30}O_2$	5	302	420	Fish oils
Docosatetrenoic	$C_{22}H_{36}O_2$	4	332	306	Brain lipids, fish oils
Docosapentenoic*	$C_{22}H_{34}O_2$	5	330	385	Brain lipids, fish oils
Docosahexenoic	$C_{22}H_{32}O_2$	6	328	464	Fish oils
Tetracosanoic	$C_{24}H_{48}O_2$	0	368	0	Brain lipids

*Tsujimoto prefers to designate this acid as clupanodonic (13).

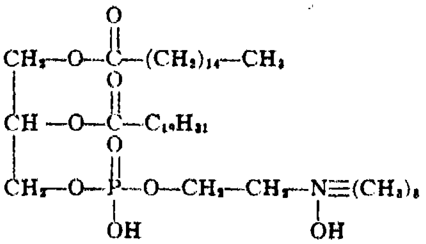
One interesting observation that may be made concerning these fatty acids is that each of them has an even number of carbon atoms. Further, all members of the series of saturated acids from four to twenty-four carbon atoms occur. The unsaturated acids include those of fourteen to twenty-two carbon atoms and of one to six double bonds. The formulae of a number of typical lipids follow:



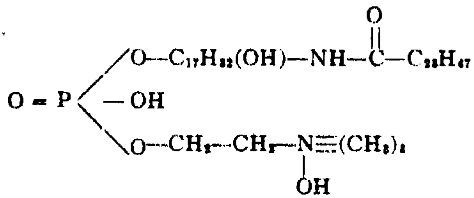
TRISTEARIN.



PALMITO-OLEO-STEARIN.



PALMITYL-ARACHIDONYL-LECITHIN.



SPHINGOMYELIN.

Although there are more than twenty fatty acids occurring in the foods we eat, the common animal body fats are composed chiefly of the glycerides of palmitic, stearic and oleic acids, and in addition generally small amounts of myristic and linolic acids; and less frequently traces of arachidonic. The animal phosphatides usually contain relatively large amounts of more highly unsaturated acids, such as arachidonic. The special function of these phosphatides may be connected in some way with their high unsaturation.

It is worth while to note here two fats which are exceptionally complex—butter fat, which contains at least eleven fatty acids, mostly saturated, and the fish oils which contain even a larger number of acids, most of them with three or more double bonds. Many speculations have been made in unsuccessful attempts to explain the complexity of these fats.

The vegetable fats and oils which are ordinarily used as foods are composed chiefly of palmitic, stearic, oleic and linolic acids. Vegetable foods are relatively low in phospho-lipids.

DIGESTION OF FATS.

Digestion of fats consists of adding the elements of water to form glycerol and fatty acids. This process begins to a very minor extent in the stomach. It is now generally recognized that a fat-splitting enzyme occurs in the gastric juice (1). Although the strong acidity and other conditions in the stomach are not favorable to the action of lipase, there does occur a certain degree of hydrolysis, especially if the fat reaches the stomach in an emulsified condition. As the food passes into the duodenum, however, the conditions change rapidly to those more favorable for saponification. The mildly alkaline juices of the intestine and pancreas and the bile rapidly neutralize the hydrocholric acid. The bile furnishes the sodium salts of glycocholic and taurocholic acid which facilitate emulsification. The intestine and pancreas secrete lipases which act rapidly on the fat as it becomes emulsified. In a relatively short time, therefore, the food fats are changed into glycerol and fatty acids. In the older treatises on digestion this reaction was explained on the basis of the formation of soaps. This appeared necessary to account for the fact that the fatty acids, which are insoluble in water, remain in solution in the digestive juices. Such a conclusion has been criticized in view of the observation that the pH of the intestine is perhaps as often below 7.0 as above; in fact it has been reported as low as 6.0. Theoretically, soaps would be completely hydrolysed and could not exist at this pH. This anomaly has been explained by the work of Verzar and Kuthy (2), who found that the bile salts will dissolve fatty acids with the formation of clear solutions even at pH 6.2.

Reference should be made at this point to the so-called "digestibility" of fats. By this is meant the extent to which fat is digested and absorbed. Earlier work had shown that if a given amount of fat were fed, approximately 90–98% of it was absorbed, the remainder being excreted. In such experiments the fecal fat was determined and estimated as unabsorbed fat. Sperry and Bloor (3), however, found that on a fat-free diet lipids continued to be excreted and, further, the character of this excretion was relatively little affected in amount or kind of fatty acids by food fat. Apparently, therefore, the normal intestine secretes certain lipids constantly. Allowing for this excretion one may infer that when any normal amount of fat is eaten, it is nearly quantitatively utilized. Exceptions to this

statement may be observed when unusually hard fats or fatty acids are fed, such as stearin or stearic acid. These do not melt at body temperature and are very imperfectly absorbed.

ABSORPTION OF FATS.

For many years it has been quite generally believed that the chief path of fat absorption was through the lacteals and lymph vessels of the intestine. The bile salts are indispensible carriers in this process. By holding the fatty acids in solution they favor diffusion through the cells and into the lymph vessels. Thence they are transported as neutral fat to the thoracic duct which empties into the left subclavian vein. The bile salts pass again into the liver which resecretes them into the bile. In this way they go through a continuous cycle of activity. Should this cycle be interrupted by obstruction of the bile duct or by artificial drainage of the bile out of the body following operations on the gall bladder, fat absorption fails. Certain definite digestive disorders are then manifested, the most important of which is the appearance of large quantities of fatty acids in the stools.

Although it is generally agreed at present that the principal path of fat absorption, at least up to 60%, is that just described, recent investigations (4) are leading to the belief that most of the remaining 40% passes into the portal blood. An appreciable lipemia has been described in portal blood during active fat absorption.

A number of important facts about the mechanism of fat absorption are now available.

(1) The fatty acids appear as neutral fats in the lymph. This change from the products of saponification in the intestine involves recombination in glyceride form. It is possible that lipases catalyse both processes. In this synthesis the bile salts probably are set free.

(2) Even if fatty acids or ethyl esters are fed, neutral fat appears in the lymph. Glycerol, therefore, is supplied in the process, either by direct synthesis or from the blood.

(3) The character of the fat appearing in the lymph represents an average between the food fat and endogenous fat. In this connection it should be mentioned that if endogenous fatty acids appear here, the 60% which can be recovered from the lymph is composed of fatty acids from the two sources; actually, therefore, less than 60% of the food fat can be recovered in the lymph.

(4) If a very finely divided emulsion of fat and mineral oil is fed, the former is almost quantitatively and selectively absorbed leaving the mineral oil behind to a degree equally quantitative. The process is, therefore, quite a specific one.

The question may well be asked "why are fats hydrolysed in the intestine only to be resynthesized before appearing in the blood?" Of course this can not be answered positively. Leathes (5) has suggested that by this process of recombination glycerides of different structure may be produced—in other words new fats more characteristic of the new organism. May there not be, therefore, some analogy between fat absorption and resynthesis and protein absorption and resynthesis? The building stones which occur in combined form in the foods are thus liberated by digestion and recombined in the new organism to form compounds characteristic of and perhaps essential to that organism.

Although small amounts of free fatty acids may be found in the blood, they occur in this fluid chiefly combined as neutral fat, phospho-lipid and cholesterol esters. Since these are insoluble in water and serum, they are carried, both by serum and cells, as an emulsion of finely divided droplets. During absorption the serum may actually be milky in appearance due to its fat content.

Following absorption fat may pass to the liver or the tissues, depending on whether it has entered the portal or systemic blood. In consequence of this, three well recognized types of transformations may occur: changes in the liver; oxidation; deposition as body fat.

THE ACTION OF LIVER CELLS ON FAT.

The normal liver contains 5% lipids, about evenly distributed as phospho-lipid and neutral fat. In 1909 Leathes and Wedell (6) showed that when cats are fed on certain fats the iodine number of the liver fatty acids is greater than that of the fatty acids of the food. Leathes suggested, on the basis of these and other results, that liver cells have the property of introducing double bonds into (desaturating) fatty acids, thus making them more reactive so that they are more easily oxidized in the tissues. Thus from stearic acid, oleic acid (or iso-oleic) would be formed; from oleic there would result linolic. Space will not permit adequate discussion of this "desaturation theory."

Suffice to say, the phenomenon of increased unsaturation may be explained on the basis of selective deposition of certain highly unsaturated acids which occurred in the oils which Leathes fed. The liver is unusually rich in phospholipids which seem to attract specifically acids of high unsaturation. The validity of the theory has been further criticized since the discovery of arachidonic acid ($C_{20}H_{32}O_2$) in the liver by Hartley (25), subsequently confirmed by Levene and Simms (7), Brown (8), Klenk and Schoenebeck (9) and very recently by Bloor and Snider (10). This highly unsaturated acid of twenty carbon atoms and four double bonds occurs in considerable amount in the liver (as high as 12% of the total fatty acids) (11). If this acid had originated by desaturation of C_{20} fatty acids, one would have to account for these acids in the food. Moreover, by desaturation one would expect to find C_{20} acids of one, two, three and four double bonds; the last, however, is the only one known to occur. Very recent reports (9) are to the effect that under certain conditions C_{22} acids with five bonds occur in the liver. Actually, the content of C_{20} and C_{22} acids in ordinary food fats is quite insignificant. It would appear more reasonable, therefore, to assume that highly unsaturated acids result from some other obscure process, probably synthetic in nature. The writer considers the evidence for desaturation as quite unsatisfactory, although, of course it has not been disproved.

Whether the fatty acids are desaturated in the liver or not, certain observations point to very active fat metabolism in this organ. Experiments have shown that liver fat changes rapidly. In starvation, for example (12), increased amounts of body fat are rapidly mobilized into the liver. Variations in food fat are rapidly reflected in the character of liver fat. Further, in certain pathological conditions such as acute yellow atrophy and miliary tuberculosis the liver may contain as much as 50% of lipids, mostly neutral fat, so that the ratio of neutral fat to phospho-lipids increases from a normal of about 1.0 to one has high as 71 (11). The forces which attract fat to this organ in such large amounts are obscure, although the abnormality may lie not in unusual attraction but in liver hypo-function—a failure of fat to be used in liver tissue. Thus fat may be attracted to liver cells by normal forces; then due to failure of liver function it remains there.

OXIDATION OF FAT.

The fat which has been absorbed into the blood and which may have passed through the liver changed or unchanged is transported to the various tissues where it may be either oxidized or stored according to the balance of supply and demand of energy available and required by the tissue cells. The forces which come into play at this point are entirely obscure; the effect of the glands of internal secretion, however, is recognized.

If fat is oxidized, we do not know as yet whether this happens to the fat molecule as a whole or whether hydrolysis precedes oxidation. In any case it is quite certain that the glycerol follows one course of degradation, and the fatty acids another.

TABLE II.

FATE OF PHENYL FATTY ACIDS FED TO DOGS.

ACID	FORMULA	EXCRETED IN URINE (Conjugated)
Benzoic	C_6H_5COOH	C_6H_5COOH
Phenylacetic	$C_6H_5CH_2COOH$	$C_6H_5CH_2COOH$
Phenylpropionic	$C_6H_5CH_2CH_2COOH$	C_6H_5COOH
Phenylbutyric	$C_6H_5CH_2CH_2CH_2COOH$	$C_6H_5CH_2COOH$
Phenylvaleric	$C_6H_5CH_2CH_2CH_2CH_2COOH$	C_6H_5COOH

(Knoop)

The classic researches of Knoop were the first to give us a clear picture of the mechanism of the oxidation of the fatty acids. From the standpoint of their chemical properties it would be expected that these acids would be attacked either on the alpha carbon atom or at a double bond. Apparently, however, in living cells the point of attack is the beta carbon atom. Knoop (14) fed to dogs phenyl derivatives of the lower fatty acids noting how they were excreted, the results of which are given in Table II.

Benzoic and phenyl acetic acids are excreted in combined form in the urine, both groups being resistant to oxidation. Phenyl propionic and valeric acids are likewise excreted as benzoic, whereas phenyl butyric appears as phenyl acetic. These results support the so-called beta-oxidation theory, which is outlined in Figure 1.

It is apparent from this outline that the normal course of oxidation is a succession of cycles involving the loss of one molecule of acetic acid (two carbon atoms) at the end of each cycle. The final product, therefore, is acetic acid which

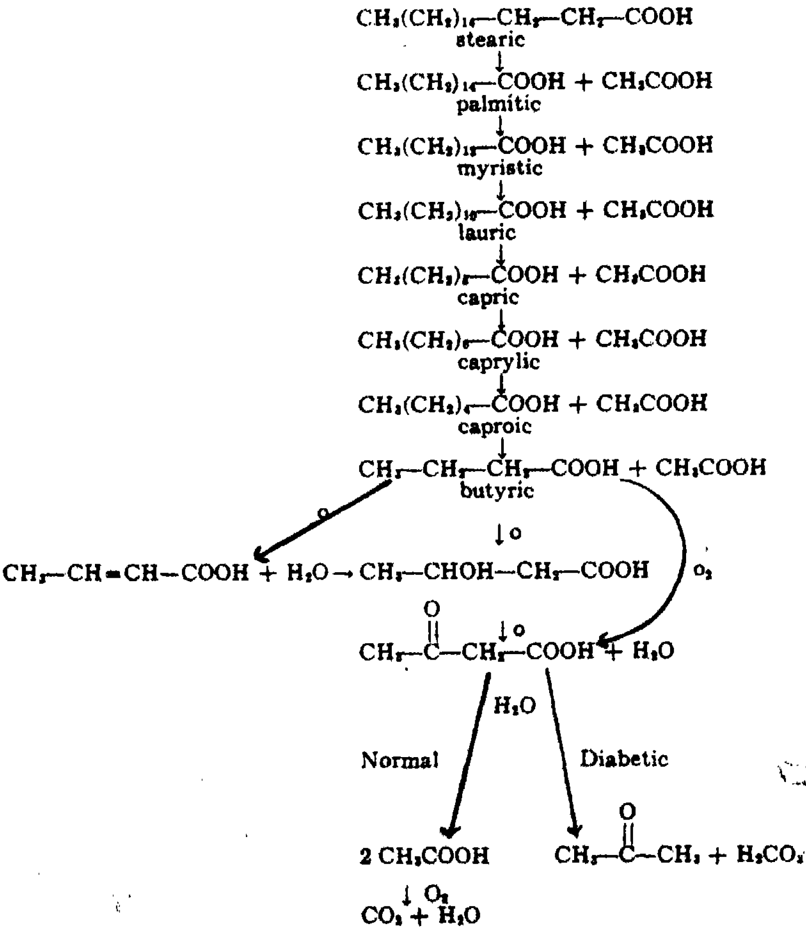


FIGURE 1.

BETA-OXIDATION OF STEARIC ACID.

eventually oxidizes to carbon dioxide and water. It is now well recognized that an intermediate of carbohydrate metabolism is essential to the completion of this process; in its absence, instead of acetic acid, other incomplete oxidation products appear, the so-called acetone bodies. Such a condition exists in diabetes.

This disease apparently results from hypofunction of the pancreas, which fails to supply adequate amounts of insulin. As the supply of insulin diminishes, less and less carbohydrate is oxidized. The substance necessary for final oxidation of the derivatives of butyric acid is no longer available. Ketogenesis results. So long, however, as there is a proper balance between sugar oxidation and fat oxidation (antiketogenesis) butyric acid is converted quantitatively into acetic acid. In the early stages of diabetes there may be enough insulin to prevent ketone formation, but not enough to prevent excretion of sugar in the urine. Ketogenesis appears only in the later and more severe stages of the disease. It is finally accompanied by severe and terminal acidosis. When the acidosis is relieved by administration of glucose and the missing intermediate is supplied by combined administration of glucose and insulin, the situation in most cases is rapidly relieved.

Aside from the evidence furnished by Knoop and by the metabolism in diabetes four other investigations serve to confirm the beta-oxidation theory:

(1) The observation of Dakin (15) that when phenyl propionic acid is fed to dogs, the intermediates predicted from the theory, phenyl-beta-hydroxypropionic acid, benzoyl acetic and acetophenone as well as hippuric acid could be detected in the urine.

(2) Dakin's discovery (16) of the analogous in vitro reaction whereby soaps may be oxidized on the beta-carbon atom by hydrogen peroxide.

(3) Embden and co-workers' experiments (17) showing that when soaps of even carbon acids were perfused through the surviving liver, acetone appeared in the blood; when soaps of odd carbon acids were perfused, no acetone was formed.

(4) The discovery by Kahn (18) that when synthetic fats with an odd number of carbon atoms were fed to diabetics, little or no acetone bodies resulted.

Beta-oxidation explains well the oxidation of the saturated acids, but how about the unsaturated acids? Oleic acid, for example, with a double bond between the ninth and tenth carbon atoms, should be more easily attacked by oxygen than stearic. In the body, however, this apparently is not true. What information is available appears to show that oleic acid, and in fact the other unsaturated acids, likewise oxidize on the beta-carbon atom. Certain of the tissues, such as the liver,

suprarenal, spleen, and brain, concentrate acids with as many as four and five double bonds. Instead of being easily oxidized, these seem to be unusually stable during life.

To summarize the oxidation of fats, therefore, it may be said that these are probably first hydrolysed into glycerol and fatty acids, the former oxidizing similar to the carbohydrates and the latter by series of beta-oxidation cycles. As a summation of this process in the normal individual a gram of average fat yields a little over nine kilogram calories of heat.

THE SYNTHESIS AND STORAGE OF BODY FAT.

We have now to consider the formation and deposition of body fat. If the energy value of the food intake exceeds that required by the body, fat is stored. This may result by synthesis either from preformed fatty acids furnished by the food or by the generation of fatty acids from carbohydrate (and indirectly from protein). Both processes are important although little is known about them. What metabolic force, for example, determines whether a fatty acid molecule is burned or stored? If burned, does this happen in the cells of the liver, in the blood cells, or in certain tissue cells? How does an excess of total energy for the organism as a whole bring about synthesis of fat from carbohydrate?

Body or depot fat may be synthesized from carbohydrates by reduction of the latter and liberation of oxygen; a speculative equation for this process follows:

$$19\,C_6H_{12}O_6 = 2\ \begin{array}{l} CH_2-O-\overset{O}{\overset{\|}{C}}-(CH_2)_{16}-CH_3 \\ | \\ CH-O-\overset{O}{\overset{\|}{C}}-(CH_2)_{16}-CH_3 \\ | \\ CH_2-O-\overset{O}{\overset{\|}{C}}-(CH_2)_{16}-CH_3 \end{array} + 4\,H_2O + 52\,O_2$$

From this equation it will be observed that from 100 gm. of glucose about 48 grams of tristearin and 47 grams of oxygen will result. Since this oxygen is endogenous, less oxygen from the air is required for respiration when fat is being synthesized by such a process, resulting in an apparent rise in the respiratory quotient. Under ordinary conditions in normal human beings the effect on the R. Q. would be slight, but in certain animals and fowls whose metabolisms are inherently fat-forming, such

as hogs and geese, if ample food is given, fat synthesis from carbohydrate causes a decided rise in R. Q. Bleibtreu (19), for example, showed that geese during luxus feeding gave respiratory quotients as high as 1.33. On starving these fattened fowls, this fell to as low as 0.72, showing that fat was being burned almost exclusively. Pembrey (20) found that marmots before hibernation eat excessive amounts of carbohydrates which are converted into and stored as fat and used during the hibernation period.

The chemical composition of stored fat is dependent on fatty acids of both endogenous and exogenous origin. Regarding the latter numerous investigations have shown that almost any of the higher fatty acids may pass into body fat, if they are eaten and absorbed at a time when fat is being stored. These include the acids which are known to be synthesized from carbohydrate, namely palmitic, oleic and stearic (and probably linolic) and in addition such common acids as myristic, linolic, linolenic, lauric, the highly unsaturated acids found in phospholipids and fish oils, arachidic and the like. In addition certain unusual fatty acids such as those which have been treated with bromine and iodine, erucic acid and chaulmoogric, when fed, are absorbed and deposited. In the case of chaulmoogric acid, the depot fat is optically active (11).

Many of these unusual acids have likewise been shown to pass into milk fat; hence they may be found in the butter fat of animals which have eaten them.

Investigations during the past few years by Eckstein (21), Powell (22) and Davis (23), have brought out the fact that certain of the acids of lower molecular weight, from C_4—C_{10} inclusive, do not appear in the depot fat; they are either completely oxidized or serve to synthesize higher fatty acids.

THE ESSENTIAL NATURE OF FATTY ACIDS.

Until quite recently fats have not been considered to be an essential dietary constituent. In (1929), however, Burr and Burr (24) described certain abnormalities in rats fed on a diet practically free from fatty acids, and believed to supply all other known dietary essentials. One of the outstanding manifestations of this condition was a dermatitis, especially noticeable on the tails. Linolic acid was found to be curative. While certain other investigators have disputed these results, they are especially interesting since they open up an entirely

new field of nutritional investigation. The future may disclose other essential functions of certain fatty acids.

On account of the limitations of space a more detailed discussion of the various factors related to fat metabolism has been impossible. There are obviously many gaps in our information on this subject. Only facts that are now generally recognized have been included. Future research on the fats and oils and especially study of that complex group called the phospholipids will not only give us a clearer picture of the details of fat transformations in cells but will disclose, no doubt, many new and important functions of these substances in living processes.

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Mosquitoes.

An addition to the taxonomic treatment of all the species of mosquitoes known to occur in N. A. A large amount of discussion is given on structures, biology, ecology, disease, transmission and methods of control. It is especially valuable for those interested in fresh water biology, public health work or medical entomology and can be used extensively in local areas for the study of mosquito problems.—D. M. DeLong.

A Handbook of the Mosquitoes of North America, by Robert Matheson. xviii+274 pp. Springfield, Charles C. Thomas. 1933.

THE RÔLE OF PROTEINS IN METABOLISM

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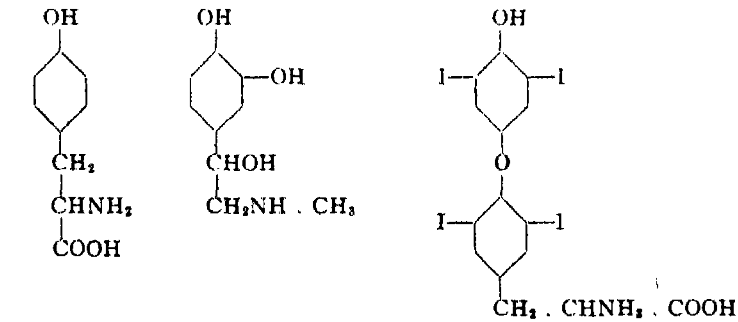
Proteins occupy a unique position in metabolism. Not only may they serve as sources of energy for the organism, but they constitute the most important raw materials out of which the complex structures of the body are built. While carbohydrates and fats are employed chiefly as fuels for the "protoplasmic fires," proteins, in the well balanced diet, serve mainly for purposes of synthesis.

Modern investigations have revealed the fact that proteins are composed of at least twenty amino acids. The amounts and methods of union of these acids vary widely in proteins of different sources. Indeed, no two proteins are exactly alike. Inasmuch as body proteins have their origin in those of the food, the latter must undergo complete disintegration before they can be utilized for synthetic purposes. This preparatory process is accomplished in the alimentary tract. At the completion of digestion the free amino acids pass unchanged into the portal circulation. Thence they are distributed throughout the organism, and serve as the substrates for the many synthetic transformations involved in the production of tissue constituents.

Very little information is available concerning the mechanism of protein anabolism. Each tissue protein is believed to be synthesized in the locality in which it is to exist. But the dominant factors which enable the cells to combine the amino acids with each other in the correct order, and in exactly the right proportions, are still beyond the realm of our comprehension. It may be shown mathematically that the number of possible isomeric proteins containing a single molecule of each of the twenty amino acids, united by the so-called peptid linkage, amounts to the incredible figure of 60×10^{20}. When one recalls that proteins are not made up of *single* molecules of the individual amino acids, but contain *many* molecules of each kind; and that several methods of union, instead of one,

may be employed in their synthesis, the number of possibilities is seen to be infinite. Thus the unerring accuracy with which specific proteins are synthesized out of the varying mixture of amino acids circulating in the blood is one of the most astounding attributes of living things.

But proteins are not the sole tissue components which originate in amino acids. Numerous non-protein nitrogenous materials arise in a like fashion. Thus, many of the hormones, and certain of the so-called "extractives" are manufactured from amino acids. Of the hormones, epinephrine and thyroxine are the best known chemically. Their structures indicate that they are probably derived from tyrosine or phenylalanine.

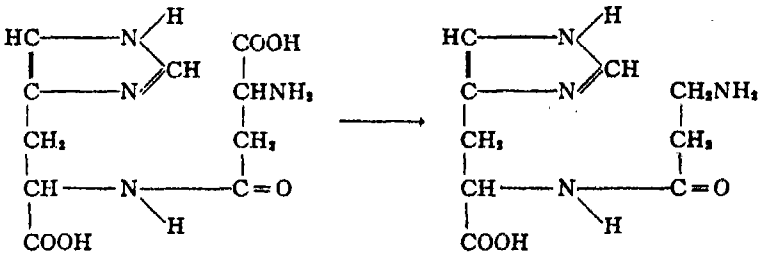


TYROSINE EPINEPHRINE THYROXINE

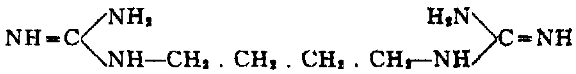
The mechanism of their formation, however, is still quite unknown. Diiodotyrosine, also found in the thyroid gland, may be an intermediate in thyroxine synthesis. The pancreatic hormone, insulin, appears to be a simple protein or polypeptid, and as such must be formed from the amino acids of the blood. Indeed, several amino acids have been recovered from the hydrolysate of crystalline insulin, notably, cystine, histidine, lysine, and tyrosine (du Vigneaud, Jensen, and Wintersteiner, 1927–28). Probably other internal secretions, such as those of the parathyroids, pituitary, and sex glands are derived from amino acids.

Of the extractives, carnosine, and its homologue anserine, isolated from muscle tissue by Ackermann and his associates (1929), are closely related to well known amino acids. The suggestion has been made that carnosine may be formed by the decarboxylation of the dipeptid, succinylhistidine. The recently described extractive, arcaine, discovered by Kutscher,

Ackermann and Flössner (1931) in the muscles of the invertebrate, *Arco noae*, may have its origin in arginine. Investigations of Ackroyd and Hopkins (1916), as well as those in the author's laboratory (Rose and Cook, 1925), appear to indicate that the purines, which are so important as components of the cell nuclei, are formed, at least in part, from the histidine of the diet.



SUCCINYLHISTIDINE. CARNOSINE.



ARCAINE.

The extractive which has attracted the greatest interest, and occasioned the most controversy is creatine. This compound is the most abundant of the non-protein nitrogenous constituents of vertebrate muscles. It has acquired new importance in recent years because of its relation to muscular activitiy. The discovery of Fiske and Subbarow (1929) that creatine in the cells, exists for the most part in combination with phosphoric acid, opened the way for the elucidation of the extraordinarily complex process of muscular contraction. While all of the details are not yet clear, and are beyond the scope of this review, apparently the first change in the muscle, and the one which is primarily responsible for the contraction, is the hydrolysis of phosphocreatine into its components. This involves the liberation of about 11,000 calories of energy per gram-molecule of phosphocreatine decomposed (*cf.* Meyerhof and Lohmann, 1928). During the recovery or relaxation phase of muscular activity, the creatine and phosphoric acid are recombined at the expense of energy set free in the decomposition of carbohydrates or fats. The process is much more

complicated than our brief outline suggests, but the above will suffice to indicate the important role played by creatine in human economy.

The recognition of the function of creatine has served to renew interest in its origin. For many years attention was directed toward arginine as its most probable precursor. Doubtless this idea arose because arginine is the only known protein component which contains the guanidine group characteristic of creatine. Space does not permit a detailed review of the many efforts to augment the creatine content of the muscles, or the creatinine output in the excreta by the administration of excessive does of arginine. The majority of such investigations have yielded negative results. Even the prolonged (6–8 weeks) feeding to human subjects of daily doses of the amino acid equivalent to 1 gram of creatine failed to provide any evidence for a transformation of exogenous arginine into creatine or creatinine (Hyde and Rose, 1929).

In recent years attempts have been made to correlate creatine with other amino acids. Brand and his associates (1929–32) report that the administration of glycine to patients with progressive pseudohypertrophic muscular dystrophy may induce a 40 per cent increase in creatine excretion as compared with the control level without glycine administration. Furthermore, gelatin, a protein rich in glycine, is said to greatly enlarge the creatine output; while edestin, relatively low in glycine, exerts little effect. These observations have been confirmed and extended by Thomas, Milhorat and Techner (1932), who report a remarkable improvement in the clinical symptoms of dystrophy patients following glycine feeding. The sensation of fatigue so characteristic of the disease is said to diminish, and the function of certain muscle groups improves to the extent that activities formerly impossible can now be performed. The authors conclude "that glycine has an important function in muscle physiology, and a significant role in the pathogenesis and treatment of this disease."

Unfortunately, not all investigators are in accord with the view that creatine excretion is stimulated by glycine ingestion. Thus Abderhalden and Buadze (1932) report that the oral administration of 15 grams of glycine is without influence upon the creatine-creatinine metabolism of the dog. On the other hand, they present data indicating that histidine and purines are the precursors of creatine. They believe that the

relationship is a direct one in which the imidazole group is transformed into the extractive.

It is impossible at the present time to harmonize the results of the glycine and histidine investigations. One should note, however, that the conditions employed in the two studies were radically different. In the glycine experiments, diseased human patients served as the subjects, while in the histidine investigations presumably normal animals were used. In human dystrophy cases there exists unquestionably a creatine deficiency in the muscles, which doubtless is an important factor in the loss of muscular strength. Such individuals would appear to be particularly well suited for studies of the origin of creatine. But even after taking these facts into account no satisfactory explanation for the contradictory findings is evident. At this time we are interested primarily in emphasizing the extraordinary role which the amino acids play, both in the chemical make-up and in the physiological funtions of living things. Their uses in the normal individual, as well as their relation to the etiology of disease, are problems the solution of which will demand the greatest ingenuity of the investigator.

The multitude of synthetic reactions in which the amino acids participate cannot but excite one's curiosity as to the quantity of protein which is required for normal human nutrition. The controversy over the problem of the optimal protein intake, which was so actively debated for many years, is familiar to all students of metabolism. On the one hand, the Voit "standard" of 118 grams of protein per day, arrived at by a statistical study of a large number of human diets, was advocated with vigor by its proponents. They pointed out in no uncertain terms the dire consequences which would befall those who had the temerity to lower the protein intake "in the light of the accumulated evidence of the ill-effects that follow in the train of chronic underfeeding." At the other extreme, the disciples of the low protein regime were equally out-spoken in their denunciation of the evils of a high protein ration. One of these investigators expressed himself as follows: "The combustion of proteid within the organism yields a solid ash which must be raked down by the liver and thrown out by the kidneys. Now when this task gets to be over-laborious, the laborers are likely to go on strike. The grate, then, is not properly raked; clinkers form, and slowly the smothered

fire glows dull and dies" (Curtis, quoted by Chittenden, 1907, p. 269). Another exclaimed: "I have already said that it would seem to be practically impossible to avoid getting protein enough! Does it not appear to be quite in the order of things that, practically, we must always get enough protein for our needs if we eat as Nature dictates? How, otherwise, could mankind have progressed so well since some hundred thousand years before Christ until A. D. 1866, in which year Voit stepped on the stage with his standard? Nature makes such careful provision in all things that there could be nothing more certain than that a means of nourishment so indispensable to all animal organisms as protein actually is must be present in such generous measure in all our food-stuffs that there is not the slightest necessity to fear that we should be unable to get an adequate supply" (Hindhede, quoted by Mendel, 1923).

In the meantime, Chittenden, in extensive experiments upon himself, his students, and others, had demonstrated that nitrogen equilibrium can be secured and maintained with a daily intake of 45 to 55 grams of protein, a quantity less than one-half that of the Voit standard. The importance of Chittenden's observations, in showing the extent to which the protein content of the diet may be reduced under suitable experimental conditions, should not be underestimated. The determination of the minimal nitrogen intake compatible with the maintenance of the *status quo* of the cells was of fundamental significance. On the other hand, it does not follow that a very low intake is, under all circumstances, necessarily the optimal. When Chittenden's studies were first undertaken in 1902 much less was known concerning the chemical composition of proteins than is recognized today. The majority of the amino acids had been discovered prior to 1900, but very limited data existed concerning their relative distribution. Consequently, there prevailed little appreciation of the fact that the nutritive value of a protein depends just as truly upon the *kind* as upon the *quantities* of its components. Under the circumstances, it is not surprising that perhaps undue emphasis was placed upon the *amount* of protein ingested, and that scant consideration was given to possible differences in nutritive *quality*. Indeed, not until the advent of the Kossel and Kutscher (1900–01) procedure for the isolation of the diamino acids, and the Fischer (1901) ester method for the separation of the monoamino acids, were reasonably adequate

tools in the hands of the biochemist for the study of the make-up of proteins. The discovery of these valuable improvements in technic marked the beginning of a new era in our knowledge, not only of the chemistry of proteins, but indirectly of their physiological value as well. It was soon seen that proteins of different sources vary enormously as regards the proportions in which their constituent amino acids occur. Frequently, one or more amino acid was found to be missing entirely. Thus gliadin of wheat proved to be deficient in lysine; zein of corn was shown to be practically devoid of lysine and tryptophane; and gelatin was seen to be lacking in tryptophane, tyrosine, cystine, valine, isoleucine, and hydroxyglutamic acid (Dakin, 1920).

The recognition of these facts naturally raised the question as to the nutritive importance of the individual amino acids. Inasmuch as all of the generally recognized amino acids occur as components of tissue proteins, obviously each must be made available, either preformed in the diet, or by synthesis in the organism from other materials. Thus protein metabolism immediately became a much more complex phenomenon than was originally supposed. Instead of being concerned with a single dietary factor, it was now seen to involve each of the so-called "Bausteine" of proteins of which eighteen had been discovered by 1912. As stated by Osborne and Mendel in 1914, "Obviously the relative values of the different proteins in nutrition are based upon their content of those special amino-acids which cannot be synthesized in the animal body and which are indispensable for certain distinct, as yet not clearly defined processes which we express as maintenance or repair." (Osborne and Mendel, 1914a). As a result of this new view-point attention was directed in several laboratories toward determining which amino acids are necessary dietary components.

Among the earlier studies of the role of the individual amino acids in nutrition those of Osborne and Mendel are of extraordinary importance. These investigators (1914a) demonstrated the indispensable nature of tryptophane and lysine by feeding diets containing zein as the sole protein. They observed that young rats upon such rations not only fail to grow but rapidly lose weight. The addition of tryptophane to the food leads to maintenance but no growth, but the inclusion of both tryptophane and lysine is followed by rapid growth. In like

manner, when gliadin of wheat serves as the sole protein of the diet growth does not occur until lysine is incorporated in the ration (Osborne and Mendel, 1914a). Unquestionably, both lysine and tryptophane are indispensable dietary components. Furthermore, it is not necessary to supply the missing amino acids in the free state. The supplementation of a zein diet with some other protein containing adequate quantities of lysine and tryptophane results immediately in growth (Osborne and Mendel, 1914b).

In a similar fashion Osborne and Mendel (1915) showed that cystine is essential. When an otherwise adequate ration carries 18 per cent of casein, young rats receiving such a food mixture grow at normal rates. When, however, the proportion of casein is progressively diminished cystine becomes the limiting factor. At a 9 per cent level, casein is incapable of inducing normal growth; but the addition of cystine renders the diet adequate, and growth promptly ensues. Confirmatory evidence for the indispensable nature of cystine has been reported from several laboratories. Johns and Finks (1920) found that the addition of cystine to diets containing phaseolin markedly improves the nutritive quality of the food. Like results were secured by Sherman and Merrill (1925) in the use of a diet of whole milk powder overdiluted with starch.

Recently, Jackson and Block (1931, 1932) have made the remarkable observation that methionine may replace at least a large part of the cystine of the diet. These results have been confirmed by Weichselbaum, Weichselbaum, and Stewart (1932). It is not yet clear whether the substitution is due to a direct transformation of methionine into cystine, or to the possibility that each of the two amino acids may perform independently certain functions in which both ordinarily participate. Nor is it yet known whether a reverse replacement of methionine by cystine can occur.

A fourth indispensable amino acid is histidine. In 1916, Ackroyd and Hopkins observed that when arginine and histidine are removed from acid-hydrolyzed casein, the resulting material is inadequate for maintenance or growth. The authors state that if either arginine or histidine is included in the ration, no loss in weight occurs, and growth may be resumed. From these results they concluded that the two amino acids are interchangeable in metabolism, but that at least one must be present in the diet. In so far as the indispensable nature of

histidine is concerned, the experiments in the writer's laboratory completely confirmed the findings of Ackroyd and Hopkins (*cf.* Rose and Cox, 1924). We were unable, however, to demonstrate an interchangeable relationship between the two amino acids. The addition of histidine to the diet invariably induced an immediate and rapid increase in weight of the animals, but the inclusion of arginine exerted no influence upon growth even when the quantity added was more than equivalent to the sum of the arginine and histidine present in casein. Confirmatory evidence in support of the essential nature of histidine was furnished by later publications from the writer's laboratory (Cox and Rose, 1926), and by Harrow and Sherwin (1926).

Thus, these four amino acids—tryptophane, lysine, cystine, and histidine—are known to be absolutely indispensable dietary components. In the absence of either nutrition fails, and eventually death results regardless of how much other food is consumed. The probability exists that either tyrosine or phenylalanine is also a required dietary component. Recently, at the University of Illinois, we have undertaken a study of the effect of combined crystallization and selective absorption as a method of removing amino acids from hydrolyzed proteins. While the investigation is not yet completed, a material has been obtained from casein which when suitably supplemented with certain purified amino acids, including tyrosine and phenylalanine, supports satisfactory growth. In the absence of tyrosine and phenylalanine, growth is impeded. At an early date we shall know whether one or both of the compounds in question must be present in the food. We are confident that at least one is indispensable. Several years ago Abderhalden (1915, 1922) presented data which he interpreted as indicating that either tyrosine or phenylalanine must be included in the food, but that the two are mutually interchangeable in metabolism. On the contrary, Totani (1916), and Lightbody and Kenyon (1928) were unable to demonstrate any relationship between the growth of rats and the tyrosine content of the diet. The conflicting results in the literature necessitated the investigations in which we are now engaged. So far our findings confirm those of Abderhalden.

In contrast to the amino acids discussed above, much evidence is available indicating that certain protein components may not be necessary. It is well known that when

benzoic acid is administered to man or to most animals it is conjugated with glycine, and is eliminated in the urine as hippuric acid. By measuring the maximum production of hippuric acid several investigators have reported that the output may carry more glycine than is found preformed in the proteins metabolized. The origin of the glycine is unknown, but it has been shown that a considerable portion of the nitrogen which in the normal metabolic processes is converted into urea, may, after excessive doses of benzoic acid, be diverted to the synthesis of hippuric acid. These findings led to the general impression that glycine may be synthesized by the organism out of ammonia and non-nitrogenous materials, or from other amino acids. As further evidence in this direction the fact has sometimes been emphasized that casein, though low in glycine, serves admirably for purposes of growth in both man and animals (Abderhalden, 1915). In like manner gliadin and zein, both of which are believed to be devoid of glycine, are made satisfactory for growth by suitable supplementation without the addition of glycine.

The evidence, however, is not all in favor of the dietary dispensability of this amino acid. Griffith (1929–30) has shown that the growth of young rats may be inhibited by the inclusion of benzoate in the diet unless glycine as such, or in the form of protein, is supplied in amounts sufficient to detoxicate the benzoate, and meet the needs of tissue synthesis. While the author believes that his data "support the idea that glycine is synthesized by animal tissues," evidently the synthesis is limited in extent. Apparently, the use of glycine for detoxication purposes may create a deficiency for the growth function unless an increased supply of the amino acid is provided. In the light of these investigations one must conclude that the prevailing idea that glycine may be formed practically *ad libitum* by the animal organism is at the present time scarcely warranted.

The relation of arginine to maintenance and growth has been the subject of several investigations. Reference has already been made to the papers of Ackroyd and Hopkins and of Rose and Cox involving the feeding of casein digests from which both arginine and histidine had been precipitated. According to Abderhalden (1922) arginine is probably indispensable in nutrition. His investigation, involving the use of mixtures of purified amino acids, is in some respects remark-

able; but owing to the difficulties experienced in the synthesis of the dietary components, the available materials were necessarily limited, and the feeding trials were few in number and of short duration. His results appear to be open to the further criticism that frequently his animals were provided with inadequate supplies of vitamins. Using an entirely different procedure, Crowdle and Sherwin (1923) report that fowls are capable of synthesizing ornithine for the detoxication of benzoic acid. Since ornithine is a component of arginine, the observation suggests that the latter also may be a synthetic product, at least in the species in question.

In view of the uncertainties inherent in the above experiments the arginine problem was attacked by a different method (Scull and Rose, 1930). This involved a comparison of the arginine intake of growing rats on an arginine-low diet and the increments in tissue arginine, in order to determine whether the latter may be accounted for by the amounts of the amino acid in the basal rations and vitamin supplement. For this purpose, hydrolyzed casein was rendered as nearly devoid of arginine as possible, and was incorporated in a diet which was administered *ad libitum*. At the beginning of the experiments, litter mates of the animals employed in the growth studies were killed and subjected to analysis *in toto* for arginine. The other members of each litter were killed and analyzed after they had received the experimental diet for a period of 64 days. In the meantime they had gained 73 to 113 grams each. Without exception the increase in tissue arginine was 2 to 3 times as large as could be accounted for by the total arginine content of the food. The findings "seem to warrant the conclusion that arginine may be synthesized by the organism of the rat, and in this species at least is not an indispensable dietary component" (Scull and Rose, 1930).

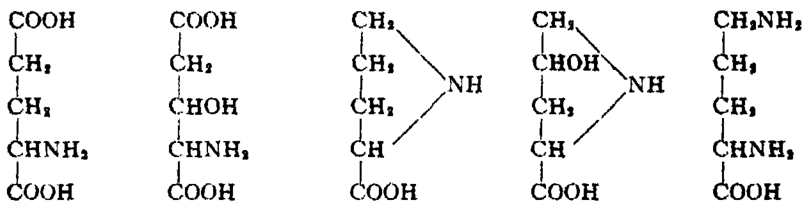
Investigations concerning the relation of certain other amino acids to nutrition have been made, but at the present time the results scarcely warrant positive conclusions. A number of years ago Abderhalden (1912) suggested that proline might be a dispensable amino acid. On the other hand, Sure (1924) is of the opinion that it is necessary. His data, however, are not very convincing. St. Julian and Rose (1932) have removed proline as completely as possible from hydrolyzed proteins by 40 extractions with hot absolute alcohol, without impairing the growth-promoting value of the resulting material. The

same investigators have precipitated the dicarboxylic amino acids, glutamic, hydroxyglutamic, and aspartic acids, without diminishing the nutritive properties of the residue. Hopkins (1916) is of the opinion that neither glutamic nor aspartic acid is indispensable. Sherwin, Wolf, and Wolf (1919) report that in the human subject glutamine may be synthesized for the purpose of detoxicating phenylacetic acid, which in man is excreted in the urine as phenacetyglutamine. Hydroxyglumatic acid is usually listed as non-essential inasmuch as edestin, which presumably is devoid of this amino acid, supports normal growth (*cf.* Osborne and Mendel, 1915; and Osborne, Leavenworth, and Nolan, 1924).

Very little information is available concerning the possible nutritive importance of hydroxyproline. Spörer and Kapfhammer (1930) call attention to the fact that several vegetable products, notably soy-bean flour, do not contain detectable amounts of this amino acid. The authors suggest that in view of the quantitative importance of soy-beans in the dietaries of oriental peoples, hydroxyproline may not be an essential constituent. More recently, Adeline (1931) has reported that rats upon diets containing 6 per cent of edestin cease growing after approximately 12 weeks, but that the addition of either proline or hydroxyproline remedies the nutritive deficiency, and induces growth. She concludes that the two compounds are interchangeable in metabolism. Unfortunately, the data are not so extensive or clear-cut as one would wish, in view of the conflicting evidence regarding the subject.

The interpretation of the results of feeding experiments in which proline, hydroxyproline, and the dicarboxylic acids are supposedly absent from the diet is rendered difficult by the lack of delicate tests for these amino acids. In such investigations one must recall that even traces of a life-essential may suffice to meet the growth requirements of the organism. It is possible that the prolines, glutamic acids, and the ornithine part of arginine may all be interchangeable in metabolism, or be capable of yielding a single essential. Thus if proline were necessary but absent from the food, one or more of the other four might be transformed into the missing amino acid, and thus prevent a dietary deficiency. The similarity in structure of the five compounds is readily seen from the accompanying formulas. Indeed, Abderhalden (1912, 1922) has frequently suggested that glutamic acid and proline may be

capable of replacing each other. We have attempted to secure evidence for such a substitution by removing all five amino acids from hydrolyzed casein (St. Julian and Rose, 1932). The resulting material was supplemented with cystine, tryptophane, and histidine, and was incorporated in the diet at a level of 11.5 per cent (including the supplements). The rats which received this ration each gained at a rate of approximately 1 gram per day. The addition to the food of arginine, glutamic acid, aspartic acid, and proline failed to accelerate the increase in body weight. In view of the low level at which the hydrolysate was fed, it is difficult to interpret the results on any basis other than that the amino acids in question are not necessary dietary components.



GLUTAMIC ACID HYDROXYGLUTAMIC ACID PROLINE HYDROXYPROLINE ORNITHINE

Very recently, Wada (1930, 1933) has reported the isolation of a new amino acid, citrulline, from a tryptic digest of casein. The compound is said to have the following formula:

$$O = C\begin{cases} NH_2 \\ NH \, . \, CH_2 \, . \, CH_2 \, . \, CH_2 \, . \, CHNH_2 \, . \, COOH \end{cases}$$

As will be observed, it is closely related to arginine. However, its presence in casein does not invalidate the experiments of St. Julian and Rose inasmuch as during acid hydrolysis citrulline is transformed into proline, and in this form is removed by repeated alcohol extractions. Final solution of the problem of the relation of the prolines, glutamic acids, arginine, and citrulline must await the use of a diet containing a synthetic mixture of amino acids known to be entirely devoid of the materials in question.

The present status of knowledge regarding the relation of the amino acids to nutrition is summarized in Table I. Of the twenty generally recognized protein components, the indispensable nature of only five has been positively established.

Two others, methionine and phenylalanine, appear to be capable of substituting for cystine and tyrosine respectively. The importance of seven is at the present time uncertain. Concerning the remaining six, available information does not warrant their classification with respect to maintenance and growth.

The bearing of the above facts upon the problem of the optimal protein intake is evident. In view of the well-known deficiencies of many proteins, notably those of plant origin, it would seem to be a safer procedure to consume more than the minimal amount necessary to maintain nitrogen equilibrium.

TABLE I.

TENTATIVE CLASSIFICATION OF AMINO ACIDS WITH RESPECT TO THEIR NUTRITIVE IMPORTANCE.

Indispensible Amino Acids	Amino Acids which have not been definitely placed, but which appear to be dispensable	Amino Acids of unknown nutritive importance
Lysine	Glycine	Alanine
Tryptophane	Arginine	Serine
Cystine (or methionine?)	Proline	Valine
Histidine	Hydroxyproline	Leucine
Tyrosine (or phenylalanine?)	Aspartic acid	Isoleucine
	Glutamic acid	Norleucine
	Hydroxyglutamic acid	

Perhaps a suitable daily intake of protein for an adult of average size might be placed at 70 to 75 grams, or about 1 gram per kilogram of body weight per day. Such a quantity allows approximately 50 per cent surplus, as compared with the average Chittenden standard, in order to insure the presence of the essential amino acids in sufficient amounts.

The fundamental nature of investigations regarding the nutritive role of the individual amino acids need scarcely be emphasized. Obviously, adequate interpretation of the facts of protein metabolism, especially with respect to the growth process, will remain impossible until the importance of each amino acid has been determined. It appears that if further information of this sort is to be secured, one must either devise more adequate methods for the quantitative removal of single components of proteins, or resort to the use of synthetic mixtures

of highly purified amino acids. The latter alternative seemed to us to be the more promising, and has already yielded results of considerable interest.

Several attempts have been made in the past to feed mixtures of purified amino acids in place of proteins, but hitherto all such efforts have met with failure. Animals upon such rations have invariably declined in weight and finally died. For about three years experiments of this sort have been under way in the author's laboratory. In formulating the amino acid mixture we imitated the composition of casein in so far as available information permitted. Nineteen amino acids were used. Hydroxyglutamic acid was the only recognized protein component not incorporated in the food. That its absence was not significant was shown by supplementing the ration with a crude fraction of protein containing the dicarboxylic acids. The rats receiving the diets rapidly lost weight during the first 12 days, and then declined gradually or maintained weight to the end of the experiments (Rose, 1931). The results were interpreted as indicating that growth-promoting proteins contain at least one essential component other than the twenty known amino acids. In line with this conclusion, it was found that the addition to the diet of 5 per cent of casein, gliadin, or gelatin in place of an equivalent quantity of the amino acid mixture, was followed after 4 days by slow growth (Ellis and Rose, 1931). Evidently the supplements furnished something which was lacking in the amino acid mixture.

Inasmuch as casein proved to be more effective in stimulating growth than did either gliadin or gelatin, the former was employed in attempting to concentrate the active material (Windus, Catherwood, and Rose, 1931). For this purpose, hydrolyzed casein was fractionated into five groups of amino acids, namely, the less soluble ones, the dicarboxylic acids, the diamino acids, the alcohol-soluble material (proline), and the monoamino acids. The first four groups proved to be almost or completely devoid of growth-stimulating activity. On the other hand, the fraction of monoamino acids carried the unknown essential in much greater proportions than does whole casein. Indeed, by a second fractionation of part of the monoamino acids a material was obtained which induced normal growth when present in the food to the extent of 5 per cent.

The compound has been concentrated by several other methods of protein fractionation. By the use of the Town (1928) copper salts procedure, the growth essential is found to be associated with those amino acids whose copper salts are soluble both in water and in anhydrous methyl alcohol (Caldwell and Rose, unpublished data). In our best preparations, the chief contaminants of the unknown substance are believed to be valine and isoleucine. Incidentally, the compound is not identical with aminobutyric acid (Foreman, 1913; Abderhalden and Weil, 1913), the amino acids described by Schryver and his associates (1925–1927), norvaline (Abderhalden and Bahn, 1930), or any of the other protein disintegration products which have been mentioned from time to time in the literature. It appears, therefore, not to have been recognized heretofore.

Already we have learned many of its properties. These are being made use of in its further concentration. We are also conducting a study of its distribution in other proteins. We hope eventually to accomplish its isolation and identification. If we succeed, as we anticipate, we shall then be in position to determine with comparative ease which of the remaining amino acids are required for normal nutrition.

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A Case of Sex-Reversal in Man.

This curious story is the account of a well-known Danish painter, Einar Wegener, who started out in life as an outwardly normal male. He married, and lived an apparently normal life for some years. Gradually, however, he felt himself becoming psychologically a woman. No homosexual tendencies were evident. This psychological change continued to the point where, after being ridiculed by many physicians, he was at last taken in hand by an eminent Dresden specialist, who removed his sex organs, found rudimentary ovaries, implanted fresh ovaries, and made of the artist an essentially normal woman. The account is said to be strictly authentic and accurate. It is written in popular style, with no attempt at scientific analysis. A foreword by Dr. Norman Haire of London is more scientific, and verifies the essential facts of the book. Certain incidents strain the imagination somewhat, such as the change in the character of the handwriting from that of a man to that of a woman immediately following the first operation. Biologists and psychologists will find this unique story of considerable interest, as there would appear to be much debatable ground as to the interpretation of the initial changes in Wegener's makeup.—L. H. S.

Man into Woman. Edited by Niels Hoyer. 288 pp., 18 ill. New York, E. P. Dutton & Co., 1933. $3.50.

CRITICAL SITUATIONS IN THE MINERAL METABOLISM OF HUMAN BEINGS AND DOMESTIC ANIMALS

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As I think of animal life, metabolism is one indivisible system—mineral metabolism existing only as we choose to concentrate our attention on the mineral elements which are involved in all metabolism; but, for convenience sake, I concede the conventional point-of-view, and have chosen to discuss those conditions relating to mineral metabolism of man and domestic animals which frequently intrude themselves upon our attention.

Since I happen to have grown up in the family of a zoologist it is my habit to think of the nutritive requirements of man and his animals as having been determined primarily during the evolution of the species, and only secondarily as modified since the dawn of civilization.

The fundamental situation with which we have to do, therefore, is the natural harmony between the animal and its environment—the adjustment between metabolism, structure, nutritive requirements and food supply—which arose by processes of evolution, and was maintained by natural selection, before the development of the human mind brought a new and profoundly disturbing element into the situation.

Incidentally, this was only yesterday, in the history of the species.

What, then, has happened—what has mankind done—to disturb this ancient harmony, and to bring upon us critical situations with reference to mineral nutrition?

These disharmonies in the nutritional affairs of human beings began with the use of fire in the preparation of food—with resulting injury to the vitamins, which, either directly or indirectly, influence mineral metabolism. This applies, especially, to vitamins A and C, which are readily damaged by heat and oxygen; vitamin B, which is sensitive to heat and moisture, and vitamin G, which is destroyed by dry heat.

Also cooking renders food pasty, so that it sticks to the teeth, and undergoes acid fermentation.

Furthermore, the cooking of food greatly diminishes the need for use of the teeth; and thus tends to diminish the circulation of blood to the jaws and teeth, and to produce underdevelopment of the maxillary and contiguous bones—thus leading to contracted dental arches, and to malocclusion and impaction of the teeth, with complications of great seriousness.

The second outstanding incident among the nutritional adventures of mankind was his adoption of agriculture as a method of living—especially because it led to a diet based upon cereal seeds and seed products, with large use of sugar. In the manner in which we use cereal foods they tend toward deficiency of virtually all nutrients that are ever lacking in the human diet except energy-producing nutriment, and vitamin E—which controls reproduction.

A third incident of significance in relation to mineral metabolism of human beings—the taking up of residence in houses, with roofs over them, and with glass windows, has added further to one of our nutritional difficulties by diminishing our contact with the short, chemically potent, ultra-violet light waves, which transform the ergosterol of the skin into vitamin D—thus endowing it with power to catalyze the most efficient utilization of calcium and phosphorus.

It is true that agriculture has also increased the available supplies of those classes of foods which are nutritionally better balanced than are refined cereal products—namely, meat, milk, fruits and vegetables—but out of the situation as a whole has come a new freedom to use nutritively deficient foods, of which we have availed ourselves, and an obligation to balance our diet, by the use of other kinds of foods, which we have not had the wisdom and the will to satisfy.

The fault is not with agriculture, but with humanity.

Manufacture, transportation, and commerce have also contributed to this new freedom and new responsibility in food selection; soil exhaustion has served to diminish the content—in some foodstuffs—of some mineral nutrients, especially iodine; and cultivated tastes dictate that we throw away valuable mineral nutrients in the skins of vegetables, in the skins and cores of fruits, in the less palatable parts of cereals, and in discarded cooking water.

Coincident with these changed conditions of diet and habitation have arisen certain minor changes in mankind himself—through diminished severity of natural selection, and

the substitution therefor of selection on bases of indifferent or of definitely disgenic effect.

This cessation or diminished severity of natural selection applies in a general way, as life has become easier, but is especially significant in relation to mineral metabolism in connection with the teeth, with fat digestion by infants, and with the function of lactation.

Thus, before the days of cooking and milling, the teeth of mankind had a definite survival value which they do not possess today, and so were maintained by natural selection at a certain level of excellence and efficiency.

The most difficult constituent of milk for an infant to digest is fat. If fat is not digested it may unite with alkali mineral elements in the alimentary tract, the products being carried out of the body in the chemical form of soaps, thus creating, in some cases, conditions of alkali deficiency and relative acidosis.

As we read the names of the many children in the families of our early American ancestors it is shocking to note the large percentage who died in infancy; but those pathetic sacrifices maintained the level of digestive competency on a higher plane than now prevails.

Similarly, the modern dairy industry has eliminated the survival value of the lactating function in womankind, and the capacity of the human mother to provide mineral as well as other nutriment to her infants has diminished. The cow helps us to "get by," and to hand on down nutritional problems of increasing difficulty.

That there has been an intensification of the severity of natural selection of human beings through a shift of emphasis from physical to certain mental and other nervous capacities, is indubitable. Thus the thousands of "jay-walkers" who awake, each year, in the land of the hereafter, must assist, willy-nilly, in the maintenance of our "sense of whereatness," but the net effect of the shift unquestionably leaves us with accentuated problems of mineral nutrition.

While, therefore, we need give no thought to the possibility of progressing backward to the nutritional situation of aboriginal man—living in natural harmony with his environment—we need at least to realize why we are where we are; which way we are progressing; and what it is practical to do about the nutritional disharmonies of the present.

CARIES.

Caries (1–5), or tooth decay of young people—an almost universal disorder of mineral metabolism among the civilized, and of immense importance in relation to arthritic, cardiac and renal disease—is at this time the subject of extensive investigation.

My view of this subject is merely that of the student of nutrition; but inasmuch as the dental pathologists are not in agreement, and have not solved the problem, we expect them to forgive us our unprofessional interest.

The most outstanding fact relating to caries is that it is primarily a disease of civilized mankind, in the sense that among many primitive peoples caries is remarkably less prevalent. Among possible contributory factors the following are considered by students of the subject, from various points of view:

1. Adhesive diets, especially such as contain much starch and sugar, yield acid, on fermentation, which destroy tooth enamel.

2. The impaction of carbohydrate foods, in situations leading to compression, contributes to fermentation effects.

3. In certain experimental work the size of food particles has seemed to be significant in relation to adhesion, impaction and fermentation.

4. Mucin plaques provide an environment favorable for decalcifying fermentation.

5. The quantities of calcium and phosphorus in the food, and the proportion of the quantity of the one to that of the other, as affecting the quantities and proportions of the same in the blood and the saliva, and especially as affecting the hydrogen-ion concentration and the acid-neutralizing capacity of the saliva, are believed by some to be significant.

6. Dietary deficiencies, in vitamins C, D and B, are said to be important in this relation; especially since deficiency of vitamin C may cause a separation of the odontoblastic layer from the dentine, and other associated abnormalities and degenerative changes; and since deficiency of vitamin D during the developmental period may cause the teeth, when erupted, to be defective in placement and structure.

7. Puberty and pregnancy are discussed as contributory causes.

8. Rickets, perhaps because of origin in part in the same conditions, is considered as predisposing to caries.

9. The presence of fluorine in foods or in drinking water is prejudicial to normality of dental structure.

But granting—for the sake of the argument—the validity of all these suggestions, I suspect that we have not yet mentioned the principal cause of caries, which appears, to my practical sense, to be disuse. The problem of caries, therefore, as I see it, is as to whether any combination of conditions as to nutrition and of environment will produce and will maintain normal tooth structure in the absence of the use to which teeth were adapted during the evolution of the species.

In this light, I doubt whether civilized mankind will ever have as good teeth as do some of the primitive peoples—unless we go back to diets which require vigorous chewing. When we chew by machinery we release the tension—physiologic and genetic as well—which, in a state of nature, maintains the teeth in a condition of normal excellence.

For the present, at least, therefore, I think that the practical question is as to the best compromise we can make with nature. To that end I would keep informed as to results of research in progress, and would attempt to prevent caries by dental treatment and dietary practice based especially upon the following:

1. The prevailing doctrine of the dental sanitarians—based upon the ideas of Miller, and those who have followed, and modified, and extended his conclusions as to the significance of the acid fermentation of carbohydrates;

2. The conclusions of Mrs. Mellanby as to the importance of vitamin D in relation to tooth development, in the prenatal as well as the postnatal stage;

3. The ideas of Bunting and associates, and many others, of the importance of a low-sugar diet, and an effective dental antiseptic.

4. The findings of Howe, as to the importance of vitamin C, and of Hanke and associates as to the efficacy of liberal use of citrous fruit juice;

5. The evidence, from many sources, as to adequate calcium and phosphorus contents of the diet; and, above all,

6. The observations of Waugh (6), and of others, on the teeth of primitive peoples, which seem to indicate the importance of vigorous use.

The Eskimos have the largest jaws and best teeth of any existing race, but after a single generation on the white man's diet, there is marked degeneration in the size and development of the jaws, and in the regularity and soundness of the teeth. Waugh concludes that "the American Eskimo is veritably paying for his civilization with his teeth."

MOTTLED ENAMEL.

Another abnormality of the teeth, the cause of which as a mineral disorder has only recently been discovered, is mottled enamel.

The enamel of the teeth becomes dull in appearance, chalky, pitted, structurally weak, lacking in cementing substance between the rods, and as a secondary effect may become variously stained.

Black and McKay (7), and H. V. Churchill (8) published early studies relating to this condition in the United States; but Margaret C. Smith (9), and associates, of the Arizona Agricultural Experiment Station, first clearly showed that the mottling of enamel is caused by fluorine in the drinking water, by producing the mottling by administering sodium fluoride.

Since this difficulty arises only from the use of drinking water from certain particular sources, the remedy is obvious.

ANEMIA.

Simple anemia is known to all as an iron-deficiency disease. The iron-poor foods of greatest importance in this relation are white flour, sugar and milk; and the foods of greatest importance because of their richness in iron are red meats and liver, green vegetables and eggs.

Anemia is common in infants (10)—whether naturally fed or bottle fed—and they respond readily to iron medication, which suggests that the aboriginal baby cut its teeth on a bone, and got some valuable shreds of meat at an early age.

The silly anti-meat propaganda of the recent years, seems about to have spent itself, and pediatric practice is swinging back toward the attitude of our parents and of our remote ancestors in the matter of meat for children.

Smythe and Miller (11) found that the percentage iron content of the body of the albino rat diminishes by a half during the suckling period, but rapidly increases to the normal

after solid food is taken, which throws light upon the situation of the human infant.

It is possible to get the supplementary iron required by infants from vegetable foods, and from drugs; but in my opinion beef juice, scraped beef and egg yolk are more natural sources of iron, and highly desirable dietary components on other accounts.

When I was a child our old-fashioned family doctor recommended steel saw filings, on bread and butter, for my sister's anemia; and the treatment was efficacious even beyond expectations, because my sister not only recovered from her anemia but became, and is today, a violinist—which testimonial for saw-filings should be noted by manufacturers of saws and files, as well as violins.

Miller and Forbes compared protein foods of many kinds as sources of iron, and found the meats to be the best and milk the poorest of those studied, in this respect.

Whipple and Mrs. Robscheit-Robbins (12) made an unusually extensive series of studies of the blood-building values of foods, with dogs as subjects. While it was clear that iron is important in this respect, it was equally clear that something else—found even in fruits—contributes to the ability of the dogs to synthesize hemoglobin.

Important later progress in this relation was the discovery of E. B. Hart and associates (13) that a trace of copper is effective as a supplement to iron for hemoglobin synthesis. Copper is contained in many, at least, but not in all foods.

Many vegetable foods contain approximately 2 parts of copper per 1000 of fresh substance—milk containing only one-third of this quantity—while some vegetables, and nuts, and cereals, contain several or many times this quantity. It is highest in the germs of seeds, which suggests its connection with the active metabolism of these parts (14).

Copper is not usually in deficient supply in otherwise practical diets, but may be so in particular cases.

Pernicious anemia is caused by an organic deficiency of the stomach, and is not within the field of this discussion of mineral metabolism.

THE IODINE PROBLEM.

One of the most important and clear-cut situations in the field of mineral nutrition is the relation of the iodine intake to the function of the thyroid, and to associated functions (15).

The thyroid gland regulates the rate at which the fundamental chemical reactions of the body are carried out, and is intimately related to the heat production.

Simple goiter is a hypertrophy of the thyroid, the first cause commonly being deficient intake of iodine.

Among the organs of the body, in addition to the thyroid, the hair, skin and nails are comparatively rich in iodine (16), and the condition of these parts is intimately related to the thyroid, and to iodine metabolism.

Seaweeds, burnt sponge, and preparations of the thyroid, which are exceedingly rich in iodine, had been used by the Chinese in the treatment of goiter for thousands of years before the discovery of iodine by Courtois in 1811.

In 1820 the chemist Dumas and the physician Coindet learned that iodine would cure some cases of goiter; but not until 1850 did Chatin advance the hypothesis that the deficiency of iodine in certain countries causes goiter; and two years later he determined that the iodine content of foods differs in accord with the iodine content of the soils on which they are grown. Recently it has been learned that the iodine content of milk and of eggs can be similarly modified, by iodine feeding of the animals which produce them.

In 1895 Baumann discovered iodine in the thyroid, and in 1914 Kendall isolated thyroxin, the active principle of the thyroid, containing 65 per cent of iodine.

Sea water contains iodine, as also do marine organisms. Deposits of salts formed by evaporation of sea water, therefore, contain iodine, but in the usual preparation of salt for nutritional or for technical use the iodine is lost. If the total iodine were retained there would be 2000 parts of iodine per billion of salt. It is much easier to restore iodine to refined salt than to retain it through the process of refinement.

The iodine content of drinking water varies enormously. McClendon and Williams, and McClendon and Hathaway found iodine in city water supplies to vary between 184.7 parts per billion in a deep well water from Mexia, Texas, and very small fractions of one part per billion in many cases. In the Scioto river water at Columbus, Ohio, they found 0.21 of one part per billion of iodine.

The iodine content of foods varies much in different parts of the United States, and the incidence of goiter likewise varies,

in general harmony with iodine deficiency of foods and drinking water.

Among the foods containing the highest quantities are oysters, clams, marine fish and Irish moss. Red cabbage is comparatively rich in iodine; whole potatoes and apples are much richer in iodine than are these foods after being peeled; and vegetables must lose a large part of their iodine into the water in which they are cooked; but immeasurably more important than the kind of food, in this relation, is the iodine content of the soil. Foodstuffs in general contain enough iodine, except as the soil on which they are grown is deficient.

In 1917 Marine and Kimball experimented in the schools of Akron, Ohio; 2190 school girls took 2 grams of sodium iodide twice a year for 3 years. Of these only 5 developed goiter, while of 2,305 girls not given iodine, and observed as controls, 495 developed goiter. The results of this experiment were so striking and convincing that iodine prophylaxis for goiter was taken up in many parts of the United States, New Zealand and India. The administration of iodine for the prevention of goiter is under government control in Switzerland and Italy.

Minimum effective iodine dosage has not been satisfactorily established. The use of iodine, and the quantity used, should be determined by a physician.

Eggenberger states that the biological minimum iodine intake to prevent goiter in human beings is 0.04 mg. per day—which would be a total of about 15 grams per year.

Hathaway advocates iodine surveys of all goitrous regions, the addition of sodium iodide to the water supplies of cities and towns, and the use of iodized table salt or tablets in rural communities.

The addition of sodium iodide to the city water supplies is practiced in several cities in this country, but it is cheaper for the people to use iodized salt, if they will do it, since only a small part of a city water supply is used for drinking.

O. P. Kimball (17) says that every iodine survey emphasizes the importance of goiter prevention during pregnancy. "We cannot stress this point too strongly and in endemic goiter districts we need the attention of the physicians who educate and direct women through this important period, and of every prospective mother. It is during pregnancy that the general

use of iodized salt will be of greatest value and should be used in every case unless otherwise directed by a physician."

"The history of this problem for the past century teaches most emphatically that the treatment of goiter is very unsatisfactory and accomplishes very little toward the control of the disease, but those attacking the problem from the viewpoint of preventive medicine—physiologists, biochemists and public health authorities—have accumulated sufficient evidence to justify the assertion that endemic goiter is the easiest known disease to prevent."

RICKETS.

Numerous surveys of infant nutrition have shown that affliction with a slight degree of rickets is exceedingly common throughout the temperate zone (18), and that a large part of these cases recover, as abundant sunshine and mixed diet replace the indoor confinement and the milk diet of early infancy, without this condition being recognized. In fact, the human infant seems to live close to the border line of rickets, because woman's milk and cow's milk as well contain, at the most, only a narrow margin of excess vitamin D, which is essential to the most efficient utilization of calcium and phosphorus.

Aside from the factors mentioned, refined cereal foods are most largely responsible for the existence of this disease, as they crowd out of the diet other foods containing more of the bone-growing requisites.

Man is one of the slowest-growing of all animals; he is adapted to and is provided with a comparatively low-calcium diet; and he is not capable of tolerating much interference with the utilization of his mineral nutrients. These facts imply that during the development of the species the conditions preventive of rickets—among which is sunshine—were dependably present in requisite quantities.

In spite of the much higher calcium and phosphorus content of cow's milk than of woman's milk the infant fed on cow's milk is much more prone to rickets than is the infant which receives its mother's milk—the calcium and phosphorus of cow's milk being not so well utilized.

The utilization of the calcium and phosphorus of milk by an infant, and therefore its tendency to develop rickets, is affected by many conditions, as to food supply and preparation, environment, digestive capacity, and rate of growth (19–24).

Some of these conditions are:

1. The quantities of calcium and phosphorus present in the diet.

2. The ratio of calcium to phosphorus in the diet.

3. The vitamin D content of the milk, and other constituents of the diet.

4. The exposure of the infant to solar radiation.

5. Rapidity of growth—which, if extreme, may contribute to the production of rickets.

6. Vigor of digestion—especially capacity to digest milk fat, which if not digested interferes with the utilization of calcium and phosphorus.

7. The time of year—as determining the intensity of the sunshine, and the vitamin values of foods.

The usual causes of rickets are combinations of unfavorable conditions as to these factors. It is normally curable by removal of the causes, and the provision of conditions sufficiently favorable for the nutrition of the bones.

Artificially fed infants, and many naturally fed infants as well, need supplementary vitamin D. It becomes a practical question, then, as to how this nutrient shall be provided—which may be in cod-liver oil, in other such oils, in concentrates prepared from such oils, in irradiated ergosterol, or in irradiated foods containing ergosterol—or it may be formed, in the skin, by exposure to sunshine or to special ultra-violet irradiation.

Irradiation by direct sunshine, or by mercury vapor or carbon arc lamps, is much more effective than is dependence on the penetration of special window glass by ultra-violet rays of sunlight.

Very many foods can be enriched in vitamin D by irradiation, and, so enriched, they are endowed with potency to heal rickets.

Milk can be enriched in vitamin D by feeding irradiated foods or drugs to the cow; but this is not a quantitatively efficient process—direct irradiation being much the most effective method of accomplishing the purpose.

The University of Wisconsin Alumni Research Foundation recently announced the perfection of an apparatus for the commercial irradiation of milk. The device consists of an upright cylinder down the inner walls of which the milk flows in a thin sheet, being exposed, during the process, to irradiation from a 12,000-watt battery of electric lamps which emit ultra-

violet light, the milk acquiring vitamin D potency about equal to that of good cod-liver oil.

It is possible to take too much vitamin D (25), with the result that calcium may be deposited in the blood vessels, heart, stomach, lungs, kidneys and muscles, and that there is an excess of calcium in the blood as well. Responsible guidance in this relation, therefore is necessary.

The prevention of rickets should begin with the care and feeding of the expectant mother (26). Her diet will affect the vitamin D content of her milk.

Among the foods deserving of mention as contributing to the rickets-preventive capacities of the child's diet, milk deserves first mention, because it is rich in calcium and phosphorus, but by itself cannot be regarded as a rickets-preventive, because it is not rich in vitamin D. Egg yolk is rich in vitamin D; butter is a fair source of D; while cod liver and other fish liver oils are very rich in this nutrient.

THE MINERAL NUTRITION OF LIVESTOCK.

The mineral nutrient problems of domesticated animals may be classified as of geographical or of physiological origin.

The deficiencies of geographical origin—which are dependent on soil and forage composition—have to do with phosphorus, iron and iodine especially, but also with calcium, and affect the different kinds of animals in accord with the proportion of forage in their respective rations, and with the magnitude of the demands for mineral nutriment which are made upon them by their different lives and functions.

HORSES.

The problems of mineral nutrition of horses depend primarily upon the facts that in their use the bones and tendons are put to such strain as to cause the many bone unsoundnesses with which all horsemen are unhappily familiar.

These unsoundnesses are ordinarily the results of maltreatment rather than malnutrition.

Under conditions of ordinarily good farm management there are no commonly obvious faults of mineral nutrition of horses. It is true that under conditions of extreme mineral nutrient deficiency horses manifest symptoms of osteoporosis, rickets, anemia and goiter, similar to those of other animals, but these conditions are comparatively rare.

Horses do not crave mineral feeds other than common salt; they are usually repelled by bone preparations, though they will sometimes take a refined steamed bone meal; but they will take and are sometimes given rock phosphate preparations—which, however, should not be fed to any animal—because of their fluorine content.

Owners of horses commonly depend on good quality of natural foods, to supply the needed mineral nutrients, and this is usually sufficient.

CATTLE.

Special concern as to the mineral nutrition of cattle (27) depends on the several-fold increase in milk production which has been accomplished by selective breeding. Cattle are rapid growing animals, and their milk is correspondingly rich in mineral nutrients. The cow, therefore, must have the supplies needed to carry on an extensive business in these substances.

The geographic mineral problem, with cattle, has to do especially with the phosphorus content of roughage, depending on the fact that there are areas of phosphorus deficient soil in many parts of the world, including several regions in the United States, but constituting a small part of the whole agricultural area.

The results of phosphorus deficiency of forage for cattle are a complication of disorders dependent upon malnutrition of the bones, depraved appetite, and generally deranged metabolism.

The administration of calcium carbonate accentuates these troubles, and the feeding of bone meal, and other phosphate foods, relieves them.

The problem of calcium content of roughage for cattle is a minor one, though there is some evidence that cattle receiving only low-calcium prairie hay for roughage may be benefited by the feeding of pulverized limestone (28).

Cattle suffer from iron deficiency in comparatively few regions, such as certain parts of Florida (29), in which the roughage is abnormally poor in iron, or in iron and copper together. The obvious method of relief is effective.

Calves do not suffer from iron deficiency, as do some other suckling animals, because they begin to eat a little hay when only a few days old—and the hay contains the needed iron.

Cattle suffer from iodine deficiency—as also do horses, sheep, and swine—in regions of low-iodine soils, foodstuffs and drinking water. This trouble appears mainly in intra-uterine development. The result, in cattle, sheep and horses, is goiter, and, in swine, also hairlessness. Iodine deficiency is easily preventable by the use of iodized salt.

Cattle may suffer from fluorine poisoning—which affects calcium metabolism, especially of the teeth (30)—but this fact seems to be practically significant at this time only in relation to the use of rock phosphate as a mineral feed.

Prominent features of the physiological mineral problem of cattle are the following:

In its practical aspects this problem relates only to the dairy cow (31–35).

It is normal for a dairy cow to be in negative calcium and phosphorus balance early in the period of lactation; later, when the mineral demands of milk production have naturally diminished, storage comes to prevail.

The annual cycle of lactation and gestation constitute the significant unit, in point of time, in this relation.

From this point of view—with ordinarily abundant milk secretion—as in average, successful production, special mineral feeds are not needed if the cow receives roughage of normal composition, in normal quantity.

Limestone and bone meal may perhaps be needed during unusually heavy milk production, or if the roughage given is restricted in quantity, or is poor in phosphorus or in calcium; but evidence as to the exact conditions which may justify the use of such feeds for dairy cows has not been established.

SHEEP.

The selective improvement of sheep has greatly increased the growth of wool by this species; and it is natural to mention sulphur metabolism in this relation, because of the high sulphur content of wool, though there is comparatively little to be said of mineral sulphur metabolism, in spite of the almost limitless ground for interest in the metabolism of organic sulphur compounds.

The nutrition of sheep doubtless requires a larger proportion of sulphur in the ration than is needed by any other animal, and it is probably more than an accident that a considerable group of brassicaceous plants, and legumes, which are rich in

sulphur, have established themselves, through the ages, as mainstays of sheep husbandry.

Sulphate and elemental sulphur have long been considered without value in the synthesis of the sulphur compounds of animal tissues, but in this relation one must not be needlessly dogmatic, because bacteria and yeasts in the alimentary tract can utilize inorganic sulphur, and the animal can digest and utilize these organisms.

Sulphur occurs in plants in many conditions and compounds—organic and inorganic—but in animals mainly as cystine, which is beta-thio-alpha-amino propionic acid, and also as methionine, which is alpha-amino gamma-methylthiol butyric acid.

According to A. T. King (36) the conversion of non-cystine sulphur into cystine, in the alimentary tract of the sheep, may depend upon bacteria which may be stimulated by iron salts in the ration, or by the sheep eating earth which is rich in iron.

Sheep suffer from forage deficiencies in calcium, phosphorus and iron—dependent on soil conditions—as do other farm animals, and likewise are benefited by the feeding of these elements in suitable inorganic compounds; but the occasions for giving mineral feeds to sheep are rare in this country—though frequent in some others.

On the borderline between organic and inorganic sulphur metabolism is the recent work, of unusual interest, by Hammett (37) and associates, which they interpret as a demonstration of the control of cell division by the naturally occurring equilibrium comprised of sulfhydryl and its partially oxidized derivatives, to which I can only allude, in passing.

SWINE.

In the mineral nutrition of swine there is no problem of soil and forage mineral deficiency, as with horses, cattle and sheep, because swine eat comparatively little roughage; but their mineral nutrition is much more likely to constitute a critical problem for this same reason—that they do eat comparatively little roughage—which is usually rich in mineral nutrients.

Other reasons for the critical situation of swine with reference to mineral nutrition are that they are raised mostly in rather close confinement, and therefore have little opportunity to gather mineral nutrients for themselves; that it is customary to

raise swine largely on low-calcium cereal feeds; and that swine develop with extreme rapidity—therefore requiring rations rich in mineral nutrients. Also they have been developed, from time to time, into physical types placing special demands upon the skeleton. In any case the heavy load of flesh which swine carry calls for strength of bones; but the refinement of skeleton which has at times been popular demands unusually dense quality of bone; at the other extreme, the so-called "big type" in the Poland China breed demanded the production of large size of bone at a rate in some cases exceeding the capacity of swine to produce normally dense bone. Also the extreme length and level back which were once popular in the Berkshire breed were found impracticable, because they placed upon the skeleton and tendons demands which they could not meet.

It is said that men will never understand the philosophy of women's hats; but men have produced some styles in pigs which suggest that men's and women's mental processes are not wholly dissimilar.

Malnutrition of the bones of swine is, under some conditions, osteoporosis—simple mineral starvation; but, under other conditions, the disorder is rickets.

The cause and the prevention of swine rickets have to do mainly with the levels of calcium and phosphorus, the proportion of calcium to phosphorus, and the vitamin D content of the ration.

The best sources of mineral nutriment for swine are leguminous roughage, skim milk, tankage, bone meal and pulverized limestone.

In addition to the skeletal problem in swine there is also, strange to say, an important problem of anemia in suckling pigs which are reared indoors, as in the winter, without contact with earth. This disorder, the nature of which was discovered by McGowan and Crichton (38) of Rowett Institute, is readily preventable by administration of iron salts, or by giving the pigs chunks of sod to chew.

POULTRY.

The following observations relating to the mineral nutrition of poultry were adapted from a statement provided by the kindly cooperation of Dr. J. E. Hunter, of the Pennsylvania Agricultural Experiment Station.

In the mineral nutrition of chickens there are two situations of special interest—rickets, and "hock disease."

Rickets, in poultry, is caused by conditions similar to those which bring about this disease in other animals, though in this relation the students of the subject have not yet reached complete agreement.

Hock disease is distinctly different from rickets. It is related to excess rather than to deficiency of mineral nutrients. Other conditions remaining the same, the percentage incidence of hock disease may be experimentally regulated in converse agreement with the bone meal content of the ration; for instance, with 2 percent of bone meal there may be an approximately 50 percent incidence, and with 4 percent bone meal a 95 percent incidence is typical.

In hock disease the tibial-metatarsal joint becomes swollen; the articular cartilage of the tibia departs slightly from its normal position; the principal tendons in this joint slip from their condiles, and the bird is permanently disabled.

Strange to say, oat hulls, or rice bran, in proper proportion in the ration, prevent hock disease in the presence of conditions which otherwise cause it; and Hunter states that he has shown that this beneficial effect cannot be attributed to the fibrous content of the supplement, or to the lowered rate of growth induced by the feeding of fibrous components. The nature of the protective substance in oat hulls and rice bran remains an interesting problem.

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Inventions and Inventors.

This volume is intended as a guide-book for those whose activities include inventive or creative procedures. Mechanical invention, chemical and electrical invention, and even psychological and biological invention are discussed. As might be surmised, the latter two discussions are highly speculative in nature. The general chapters on invention, inventors, patents, and the financing of such undertakings will be of interest to anyone with new ideas and the urge to exploit them.—L. H. S.

The Inventor and his World, by H. Stafford Hatfield. v + 269 pp. New York, E. P. Dutton and Co., 1933. $2.40.

METABOLISM AND DISEASE

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The preceding lectures of this series have been particularly instructive to one interested in metabolism primarily from the standpoint of disease. They have added to the principles which are employed in determining metabolic changes. Likewise they have cleared certain ill-understood manifestations of morbid processes. In this manner has advancing metabolic science enabled medicine better to comprehend the nature of disease. Awareness of this newer knowledge enables the surgeon, if he wishes, to escape an altogether too prevalent empiricism.

A number of diseases have been designated "idiopathic". This has resulted from a lack of understanding of the nature of the cause of the disturbance. As knowledge advances and as underlying principles are recognized, "*new*" diseases are gradually being separated from this group, isolated and defined as entities. It is obvious that such diseases are not "new". It is our discernment that is new, as an enlightened search of the older literature soon reveals. Metabolic investigation has been of especial service in this manner. Such a "new" disease is hyperparathyroidism.

HYPERPARATHYROIDISM.

Over fifty years ago a disabling, deforming disease of bone was recognized and reported (1). At first this was regarded as a peculiar form of osteomalacia, a wasting bone disease. Other instances were observed. In 1891 it was thoroughly described and given place as a disease entity by von Recklinghausen (2). It became further differentiated from other diseases presenting bone lesions. Owing to the presence of demonstrable areas of localized bone absorption, many of which contained loose fibrous tissue, it became known as osteitis fibrosa cystica. Since the bone cysts, rather than solitary, were widespread in their distribution, the modifying term "generalizata" was

added. Thus "von Recklinghausen's disease of bone" came to be recognized as involving the skeleton as a whole.

The earlier descriptions were of more advanced instances of this rare disease. These were, and are, the more readily recognized. In advanced cases the bones become demineralized. This is readily demonstrated by roentgenologic study. The local cysts may even contain areas of giant cells (3). There results an obvious weakening of the bones and an increased incidence of fractures.

In the early descriptions of the disease no mention is made of the existence of an associated parathyroid tumor. This is quite understandable, since the parathyroids were not discovered until 1880 (4). Hypoparathyroidism was only recognized in 1896 (5). The relationship to calcium metabolism was established even later (6).

Askanazy had doubtless seen an instance of the disease with an associated parathyroid adenoma (7). However, it was Erdheim's experimental studies that definitely related the parathyroids to bone disease (8). Erdheim, however, had regarded the parathyroid enlargement as a compensatory hyperplasia, and as subsequent to the bone disease, which he considered primary. Under the influence of Erdheim's hypothesis, Mandl (9) had made a homoplastic transplant of four normal parathyroids to a bed-ridden patient with von Recklinghausen's disease. The clinical symptoms, however, were definitely aggravated. Mandl then decided that the enlarged parathyroids might be the cause and not the effect of the disease. At a subsequent operation he discovered a parathyroid tumor, behind the thyroid gland. He removed it and also the transplanted parathyroids. This was followed by steady clinical improvement of the patient.

Following this striking clinical proof of the essential nature of von Recklinghausen's disease of bone, numerous similar instances were reported. About forty cases have now been studied and recorded (7, 12). Barr and Bulger (10), on the basis of clinical and experimental evidence, were the first to apply the term "hyperparathyroidism" to this rare disease.

The disease has now been reproduced experimentally (7) by administering, both acutely and chronically, Collip's (11) parathyroid extract known as "parathormone." It is even possible to produce, particularly in dogs, the characteristic bone cysts, as well as the evidence of generalized demineralization.

There are several diseases which are characterized clinically by the demineralization of bone. Compere (12a) has tabulated the principal features of seven of these. According to his studies, "hyperparathyroidism" presents five pathognomonic findings. These are: 1. A tumor of one or more parathyroids. 2. A negative calcium balance. 3. Increase in the urinary excretion of calcium. 4. Retention of sulphur. 5. The remaining parathyroids are normal grossly and microscopically. It may be added that the serum calcium is usually, although not always, elevated, and that the serum phosphorus is usually, although not always, lowered.

In this manner, too briefly sketched, has a "new" disease arisen from the "idiopathic" wasting diseases of bone. It is clearly a disorder in which there is a disturbance of calcium metabolism. The cause is a hyperfunctioning parathyroid.

IODINE METABOLISM AND THYROID DISEASE.

That a relation exists between the function of the thyroid gland and the metabolism of iodine is now undeniable. Within the past decade the nature of this relationship has been greatly clarified. Clarification has resulted, to a certain extent, from studies which have been made upon the effects of iodiniaation in the treatment of goiter (13). More has been learned, however, from the development of more accurate micromethods, permitting the determination of the minute amounts of iodine normally present within food, water, and air, as well as within the blood, urine and tissues (24).

The ancient use of burnt sponge in the treatment of goiter was a fortunate empiricism. Courtois discovered iodine in 1811, due to the fact that he used a lye made from seaweed, and the contained iodine corroded his copper vats. Soon after, Davy demonstrated the presence of iodine in sponges and other forms of marine life. As a natural consequence Coindet, a Swiss physician residing in Geneva, used iodine, in 1820, for the treatment of goiter (14). Since Coindet, iodine and the goiter problem have been inseparable.

Numerous subsequent investigations led to Prevost's theory in 1849. This indicated a relationship between iodine deficiency and thyroid overactivity resulting in goiter. The theory was substantiated by the work of Chatin (15). This led to the extensive use of iodized salt by the French in 1860, in an attempt to prevent the occurrence of goiter in the school children of

three departments of France (14). The ill results of this huge experiment led to abandonment of the practice. Advancing knowledge concerning the relationship between iodine and thyroid disease was consequently checked, and during the ensuing thirty-five years there arose other theories as to the nature of goiter. It was during this thirty-five year period (1860–1895) that the infection theory gained credence, doubtless due to the contemporary influence of Pasteur.

Impressed by the demonstrated interrelationship between the thyroid, goiter, and iodine, Theodore Kocher, eminent Bernese surgeon, assigned to one of his assistants the task of investigating the presence of iodine within the thyroid gland. The assistant failed. He found no iodine within the gland and thus missed making a discovery of fundamental significance. In 1895 Baumann, a biochemist, demonstrated the presence of quantities of iodine within the thyroid gland (16). As final scientific proof, Baumann actually isolated this iodine from the thyroid and demonstrated it, in its characteristic violet vapor form, in tubes (17). The significance of his contribution was quickly appreciated. Iodine in its relation to thyroid function recovered its lost prestige. The prophylactic use of iodine, properly controlled, in goiter, again became popularized. Marine and his associates (18) obtained excellent results in Ohio, as you are aware, by administering small doses of iodine. Other investigators in other countries were likewise successful (19). The lost ground was apparently recovered.

In 1919 Kendall isolated thyroxin (20). This crystalline substance, isolated from the thyroid gland, possessed certain of the physiologic properties of the dried whole gland. The isolation was repeated by Harington (21), who determined the correct molecular structure. Working from this structural formula, he succeeded in synthesizing thyroxin (22). Thyroxin, natural or synthetic, is 65 per cent iodine.

It seems obvious that the next forward step in determining more definitely the relationship between the thyroid and iodine should be an investigation of iodine metabolism. At once there arose the necessity of developing methods sufficiently sensitive, and at the same time sufficiently accurate, to determine the minute amount of iodine normally present within the ingesta, within the blood, within living tissues and within the excreta. This problem had been previously attempted by Chatin (15); however, his work had been doubted.

The iodine content of the thyroid gland itself was readily determined by the older, coarser methods, owing to the relatively high iodine concentration (23). This did not hold for the blood. Davy had originally separated and determined the iodine present in sponges by first ashing the organic material. The principle of his method, with various modifications, has since been widely followed. For decades, numerous methods had been devised for the determination of the iodine content of food, water, and air (24). None of these, however, was sufficiently delicate even to detect the minute amount of iodine normally present within the ordinary quantities of blood used for analyses.

During the first decade of this century advancing goiter research created an acute demand for an adequate micromethod. In 1922 the Swiss Goiter Commission, consequently, requested von Fellenberg, chemist of the Bureau of Hygiene, to develop such a method. He devised, perfected, and eventually synthesized the known existing quantitative procedures into an adequate micromethod for the determination of iodine (24). This will determine one ten-thousandth of a milligramme, 0.0001 mg. Two of von Fellenberg's pupils, Sturm (25) and Lunde (26), soon applied this method to a study of the blood, particularly in patients with thyroid disease. Thus was opened the way for a new approach to our conception of thyroid function in health and disease.

Following Baumann's discovery, numerous investigators had determined the iodine content of normal and of goitrous thyroid glands (27). Kendall and others (28) had observed a seasonal variation in the iodine content of the thyroid. This was lowest in the winter and spring and highest in the summer and autumn. These findings, by the way, correspond to what we now know of the associated blood iodine level (Sturm).

In investigating the intermediary metabolism of iodine, it was inevitable that attention should be directed to the blood. In 1899 Gley and Bourcet (29) unable to demonstrate iodine in 100 to 200 cc. samples, used a liter of dog's carotid blood for their analyses. They thus were able to demonstrate the presence of iodine in mammalian blood. They regarded it as a normal constituent of the blood stream. This was subsequently confirmed by some but denied by others (30). It was a matter of method. The earlier analyses were quantitatively inaccurate as judged by the results of modern micromethods.

The "*first modern figure*" for the blood iodine is that of Kendall, 13 gamma per cent for ox blood (31). The normal iodine content of blood is so minute that the term *gamma* is used to designate its unit. One gamma equals one one-thousandth of a milligramme, 0.001 mg. The normal iodine content of human blood in the Chicago district we have found to be about 12 gamma per cent, or .012 milligrammes in 100 cc. of blood (32). Attempts have been made at separating the iodine of the blood into an alcohol insoluble "organic" portion or one presumably in protein combination, and an "inorganic" portion or one which is alcohol soluble (33).

From an extensive investigation which our group has made during the past four years, it is apparent that a definite inter-relationship exists between thyroid activity and the blood iodine niveau (34). In this our findings confirm those of Sturm and of Lunde. I wish to present, at this time, certain of the results which we have obtained in determining the blood iodine level of normal individuals and of over 150 patients with various diseases of the thyroid gland. These analyses have all been made by Dr. Chester Davis, Dr. Versa Cole, and Mr. Francis Phillips. Dr. Davis spent, at the commencement of our work, five months experimenting with and developing the method before it was applied to the blood of patients. The method he developed (35) was essentially that of von Fellenberg (24). Mr. Phillips has made important additions. It is possible to determine one ten-thousandth of a milligramme of iodine. Contrary to general opinion, the technical difficulties encountered concern mainly iodine loss rather than contamination.

Before considering the blood iodine data, several facts should first be recalled and emphasized. The diffusely enlarged, hyperplastic gland of untreated Grave's disease is ordinarily iodine-poor (27). It contains, as a rule, less iodine than the normal thyroid gland. Little or no colloid is present (36). This represents the overfunctioning thyroid. The amount of iodine within the gland increases from three to ten times following the customary preoperative administration of iodine (Lunde and Holst). This is accompanied by filling of the alveoli with colloid.

The normal blood iodine ranges from 8.5 to 16.2 gamma per cent, averaging 12 gamma per cent (37). This statement is based upon 34 determinations made upon twenty-eight

individuals with no evidence of thyroid dysfunction. Eight determinations made on six normal persons ranged between 8.9 and 13.8 gamma per cent, averaging 12 gamma per cent. It is necessary to determine the blood iodine of women in the intermenstrual period, since there is a rise in the blood iodine during the onset of menstruation (38). Thirteen determinations made on ten hospital patients on ordinary hospital diets revealed a range of from 8.5 to 13.4 gamma per cent and an

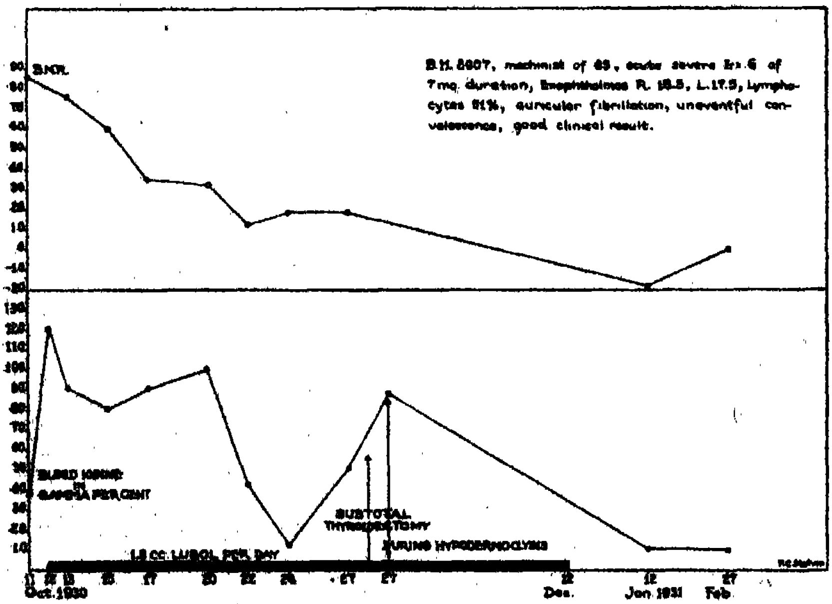

Figure 1.

The Blood Iodine in Exophthalmic Goiter.

The blood iodine is elevated previous to medication (normal = 12 gamma per cent). It rises upon lugolization. It is high during iodine administration by hypodermoclysis. It falls to a low normal level subsequent to subtotal thyroidectomy and the cessation of lugolization. The elevated B. M. R. falls upon lugolization. It remains low after an adequate thyroidectomy.

average of 12.3 gamma per cent. Iodized salt was not used in the hospital diet. No significant change was noted in the blood iodine of patients with cancer. Thirteen determinations made on twelve patients in the Out-Patient Department gave a range of from 8.5 to 16.2 gamma per cent, averaging 11.4 gamma per cent.

In acute hyperthyroidism, known clinically as Grave's disease, there is a marked elevation (Figure 1) of the blood

iodine (39). Sixteen determinations made on eleven of these unmedicated patients revealed a range of from 16.9 to 40.1 gamma per cent, or an average of 27.1 gamma per cent. The average basal metabolic rate in these eleven patients was plus 50. No direct correlation was observed between the height of the basal metabolic rate and the blood iodine level. We have thus far made no attempt to fractionate this high blood iodine into "organic" and "inorganic" portions.

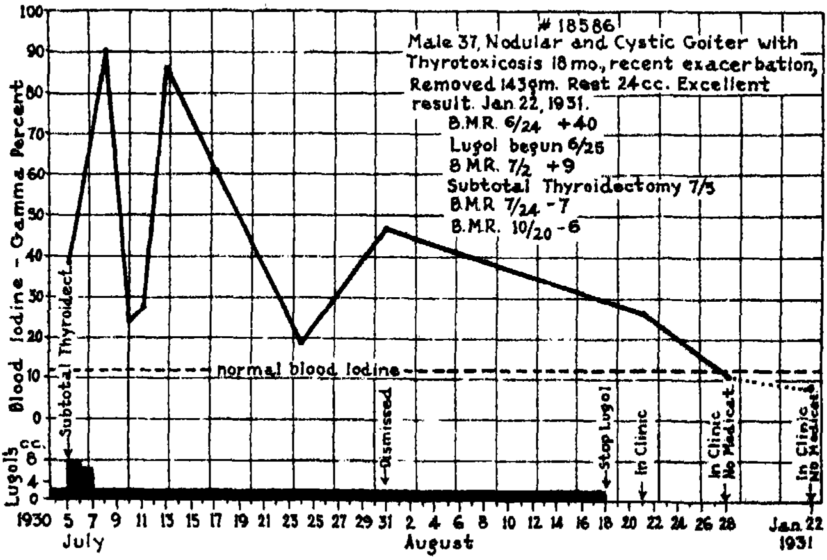

FIGURE 2.

THE BLOOD IODINE IN TOXIC NODULAR GOITER.

Following subtotal thyroidectomy the blood iodine remains elevated so long as lugolization is continued. It falls to a low normal level after adequate thyroidectomy and cessation of iodine medication.

After an adequate thyroidectomy, with subsequent relief of the symptoms of the hyperthyroidism, the elevated blood iodine falls to a low normal range (Figure 1). Fifteen determinations made on twelve operated patients revealed a range of from 8.7 to 14.3 gamma per cent, or an average of 10.4 gamma per cent. The basal metabolic rate in these patients averaged minus 6.

In the more chronic and less severe form of hyperthyroidism occurring in patients with nodular goiters, the blood iodine is also elevated, (Figure 3). Eleven determinations on eleven of these patients revealed a range of from 13.1 to 38.1 gamma per cent, averaging 22 gamma per cent. The average basal

metabolic rate was plus 26. Thus chronic hyperthyroidism is accompanied by a lesser elevation of the blood iodine, as well as by a lesser elevation of the basal metabolic rate. Likewise,

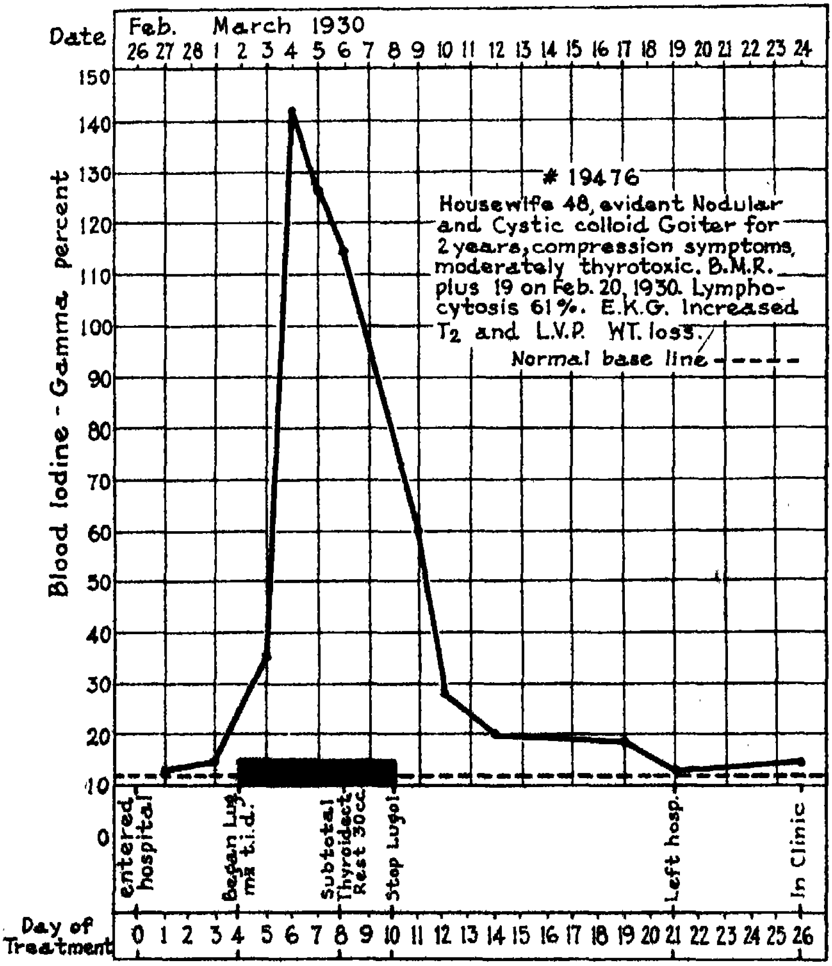

FIGURE 3.

THE BLOOD IODINE IN MODERATELY TOXIC NODULAR GOITER.

The premedication level is above normal. A marked rise occurs upon lugolization and continues so long as iodine is administered. There is still some elevation two weeks after thyroidectomy and the cessation of lugolization.

in toxic nodular goiter, no direct correlation was observed between the blood iodine and the elevated basal metabolic rate. After these patients have submitted to an adequate

thyroidectomy, with the subsequent symptomatic relief, the blood iodine falls to a low normal level, (Figure 2). Twenty-three determinations, made on twelve of these patients, revealed a range of from 5.5 to 16.9 gamma per cent, averaging 10.4 gamma per cent. The average basal metabolic rate in these twelve patients was minus 4. It is thus apparent, that when hyperthyroidism is controlled by adequate removal of the over-functioning gland, the elevated blood iodine falls to a low normal level. This is shown in Figures 1 and 2.

If the thyroidectomy is inadequate, the blood iodine does not fall to a low level. It also remains elevated between the stages of a two stage lobectomy. In four determinations made on four of these patients, the range was from 19.4 to 32 gamma per cent, averaging 26.1 gamma per cent. The average basal metabolic rate in these patients was plus 31.

Nontoxic nodular goiter, presenting no symptoms of hyperthyroidism, is accompanied by a low normal range of the blood iodine. In eighteen determinations made on ten of these patients, the range was from 6.3 to 12.7 gamma per cent, averaging 10.4 gamma per cent. The average basal metabolic rate in these ten patients was minus 4. Following partial thyroidectomy for nontoxic, nodular goiter, little eventual change occurs in the elevation of the blood iodine. This is shown in Figure 3. In these patients more of the thyroid is left behind than in those patients with toxic goiter.

The blood iodine is variable in its elevation in various other diseases. It is definitely elevated in lymphatic leukemia. It is to be remembered that in this disease there is an elevation of the basal metabolic rate, of the lymphocyte count of the blood, and that beneficial effect ensues after iodine treatment. We may now add that the blood iodine is elevated (40). This striking parallelism between hyperthyroidism and lymphatic leukemia is worthy of further investigation.

In those patients who, normal metabolically, develop exophthalmos subsequent to an adequate thyroidectomy, the blood iodine is normal (40). In unmedicated hypothyroidism the blood iodine is low (40). In eleven determinations made on eight of these patients, the range was from 7.2 to 11 gamma per cent, averaging 9.4 gamma per cent. The average basal metabolic rate was minus 16. When these patients are given desiccated thyroid by mouth, there occurs, along with the clinical improvement, a rise in the iodine content of the blood,

It is difficult to dissociate this rise from the amount of iodine administered in the desiccated thyroid. Immediately following administration, there ensues a sharp rise in the blood iodine. This precedes that of the basal metabolism. In patients with treated hypothyroidism the blood iodine is elevated. This elevation is greater at first and becomes stabilized at a high normal level after continued desiccated thyroid administration.

Members of the same family, with varying states of thyroid function due to disease, present striking variations of the blood iodine. In one family investigated, the blood iodine of the mother was high. She had toxic nodular goiter. The blood iodine was normal in one son with no evidence of thyroid disease and low in another son and daughter who had diffuse goiters with hypothyroidism.

Immediately following a thyroidectomy, there ensues a fall in the blood iodine. It remains to be seen whether this is directly the result of the removal of an excess amount of the secreting thyroid tissue.

In children with acute hyperthyroidism, the blood iodine is definitely elevated (41). It responds to iodine medication and thyroidectomy as does the blood iodine in adults. Subsequent to thyroidectomy for toxic goiter, the blood iodine remains high so long as iodine medication is continued. Upon cessation of iodine medication, however, it falls to a low normal level, provided an adequate thyroidectomy has been made. This effect is presented in Figure 1.

Judging from an extensive clinical study of the blood iodine in patients with varying states of thyroid activity, there is a definite relationship between the level of the blood iodine and thyroid function (40).

DEMINERALIZATION.

The significance of other blood electrolytes in relation to disease is also deserving of our attention. Changes in the normal concentration of certain ions, or fluctuations in the balance between others, are associated with certain morbid processes occurring spontaneously or produced experimentally. Subsequent to surgical operations, during which ether is used as the anesthetic, there ensue extensive changes in the calcium-potassium ratio of the blood (42). These are accompanied by a period of post-operative lethargy, and a marked tissue thirst. Calcium loss, sufficient to result in osteoporosis, may ensue

following the continuous loss of bile subsequent to the establishment of a chronic biliary fistula (43). The blood bromine is now receiving clinical attention (55).

The chloride of the blood, since it is the most prevalent ion and the more readily determined by various analytical methods, has been particularly studied. An extensive literature has already accumulated. The hypochloremia subsequent to upper intestinal obstruction has been frequently confirmed (44). A similar lowering of the blood chloride is associated with the fatal effect of the total loss of gastric juice (45). Orr and Haden (46) report that the blood chloride is also lowered in dogs with fatal experimental peritonitis. We have observed a low blood chloride accompanying a strangulated hernia of the omentum, and in cases of acute diffuse peritonitis. The blood chloride is low despite the blood concentration of the so-called toxemia following extensive superficial burns (47). The fluid within the blisters has a chloride concentration higher than that of the blood plasma. The symptoms of heat cramps, called also miner's cramp, stoker's cramp, or fireman's cramp, are initiated by a marked loss of perspired chloride and are prevented by drinking saline or relieved by the administration of salt solutions (48). The symptoms of "water intoxication" as studied and described by Rowntree (49) are relieved by saline intravenously. In pneumonia the serum chloride is lowered and the urinary excretion of chloride decreases or even fails. In view of these and of other similar clinical findings, it appears that the disturbance in chloride metabolism associated with these morbid states is possibly of more than subordinate importance.

Various crystalloids may be readily dialyzed away from the circulating blood through celloidin tubes inserted in the course of the blood stream. This process, called *vividiffusion*, was devised by Abel, Rowntree, and Turner (51). Dialysis also readily occurs through the peritoneum. Cohnheim (52) found that chloride soon appears in glucose solutions injected intraperitoneally in rabbits. This is likewise true when varying concentrations of cane sugar are employed (53). When distilled water is injected intraperitoneally, a higher per cent of chloride, up to 0.63 per cent, is deviated from the blood stream and the blood chloride falls (54). The intraperitoneal water soon becomes isosmotic and obtains up to 1.5 per cent of albuminous substance as well as numerous cells. Achloride electrolytes, as

well as organic crystalloids, are likewise dialyzed from the blood stream (54). Consequently, it has been possible, experimentally, to demineralize rabbits by perfusing distilled water through the peritoneal cavity (50, 60).

The transperitoneal perfusion of distilled water at body temperature at the rate of 500 cc. per hour results, within an hour, in an increase in the respiratory rate and the appearance of localized fibrillary twitchings of the muscles (50). These become more generalized, and are followed by clonic and tonic convulsions of increasing severity. Spasmodic contractions of the diaphragm occur, and the animals ordinarily die after from two to five hours of perfusion. The blood chloride falls. The carbon dioxide combining power of the plasma falls. There is a moderate rise in the N. P. N., and a slight elevation of the urea. The secretion of urine soon diminishes and finally completely ceases. The development of the symptoms and of the lethal effect are not due to hypoglycemia since addition of 0.12 per cent glucose to the perfusion water in other experiments was without preventive effect.

Transperitoneal perfusion of Ringer's solution, or of isosmotic pure sodium chloride, with or without glucose, resulted in the development of no muscular twitchings or convulsions. These animals were alive and in good condition when the experiments were terminated at the end of eight to ten hours. The blood chloride was slightly elevated. There was a continuous secretion of urine, or even a moderate diuresis. In one of the sodium chloride perfusion experiments the serum calcium fell to 2.9 mg. per 100 cc. of blood without evidence of tetany.

The transperitoneal perfusion of 4.2 per cent glucose resulted in increased respirations, muscular twitchings and tremors, convulsions and eventually death in from two and one-half to seven hours. The terminal blood chloride was low. There was an enormous rise in the blood sugar. Perfusion of 0.45 per cent sodium chloride and 2.1 per cent glucose had no such lethal effect and the animals lived.

The perfusion of Ringer's solution with glucose, but *without sodium chloride*, resulted in increased respirations, muscular twitchings and convulsions and eventual death. The blood chloride fell. The secretion of the urine diminished and then ceased.

An adequate amount of sodium chloride was eventually supplied to the blood stream during the transperitoneal per-

fusion with distilled water. This was accomplished by the timed intravenous injection of 2.5 per cent pure sodium chloride by means of the Woodyatt pump. It was found best to inject a 2.5 per cent solution of pure sodium chloride at the rate of 1 cc. per minute into one of the cannulated jugular veins. When too concentrated solutions were used, e. g., 9.0 per cent, thrombosis occurred locally and was even followed by pulmonary embolism. If the solution is too dilute, sodium chloride is not supplied as rapidly as it is dialyzed away; also, too much water must be simultaneously injected. The continuance of renal secretion is apparently an important factor in the success of these experiments.

By this method it was possible to keep the animals alive. One animal lived seventeen and one-half hours, more than five times as long as during the transperitoneal perfusion of distilled water alone. Occasional mild muscular fibrillation was noted, but no severe tremors or no convulsions. A marked diuresis was observed. There was a slight fall in the whole blood chloride. There was no tetany although the serum calcium fell to 3.8 mg. per 100 cc.

In succeeding experiments the combined intravenous infusion and transperitoneal perfusion were similarly maintained for twelve hours without the development of notable symptoms. At the end of that time the intravenous injection of pure sodium chloride was stopped, but the transperitoneal perfusion of distilled water with glucose continued. Muscular twitchings then developed, became more severe and finally convulsions occurred and death followed after five hours of transperitoneal perfusion alone.

It is difficult to make any greatly inclusive judgments as to the bearing of these experiments upon our daily clinical problems. So much is unknown, particularly regarding the associated physico-chemical blood changes. Consequently, it is with some hesitation that I shall consider their significance in four conditions which we encounter in the post-operative management of our surgical cases: dehydration, anuria, tetany, and hypochloremia.

Dehydration is frequently evoked to explain the results of the extensive loss of fluid by profuse sweating, in extensive burns, by vomiting, diarrhea, or through the various gastro-intestinal fistulae. On the other hand, we must be careful to remember that all these fluids have a considerable mineral

content which likewise is simultaneously lost to the organism. In replacing this fluid loss, we do not administer distilled water, but rather salt solutions.

During the past few years, we have analyzed chemically the body fluids found in various morbid conditions such as ascites, hydrothorax, pericardial effusion, hydrocele, blisters following burns, synovial effusions, effusions in bursae, ovarian cysts and tendon sheaths (56). Nearly all of these have a high mineral content. The copious intestinal fluid found in the paralytic ileus accompanying peritonitis has a high mineral content, likewise the intestinal fluid above a mechanical obstruction or that draining from a jejunostomy. The loss of these fluids is thus accompanied by a considerable loss of minerals. As a consequence together with the dehydration, demineralization is to be considered. These experiments demonstrate certain of the effects of demineralization as produced by peritoneal dialysis. Consequently, in our replacement therapy, we should be aware of the demineralization associated with the loss of body fluids.

The treatment of the recurrent ascites of portal cirrhosis by biweekly paracentesis of the abdomen is of interest in this connection. So much as ten liters of fluid may be obtained at each tapping. It is not generally recognized that this fluid has a high mineral content. We have determined this as about 0.7 per cent (56). Thus every two weeks over 70 grammes of minerals are removed from the patient, as well as protein and other crystalloids.

The anuria associated with intestinal obstruction is commonly thought to be due to a "toxemia" which in some manner depresses the function of the kidney. Our experiments show, when the organism is being demineralized by the transperitoneal perfusion of distilled water, that the secretion of urine soon decreases and finally ceases. That this is not due to some toxic action upon the kidney is shown by the fact that the kidney resumes function upon the simultaneous administration of timed adequate salt solution intravenously (57). In a study of the mechanism of diuresis we found it possible to inhibit or even block the normal action of a theophyllin diuretic administered intramuscularly, by simultaneously injecting distilled water intraperitoneally (58). This intraperitoneal distilled water caused a rapid dialysis of salts from the blood stream and tissues into the artificial transudate. The minerals were thus

deviated. When the artificial transudate became isosmotic, a diuresis ensued. Diuresis is dependent to a great extent upon the state of the tissues (58). Changes in this state due to mineral loss may readily affect the function of the kidney. In this manner we would regard certain cases of postoperative anuria as due to a depletion of blood or tissue electrolytes rather than as resulting from some "toxic" or "reflex" (59) effect.

Various forms of tetany have been recognized clinically. Most commonly it is regarded as being associated with hypoparathyroidism and a lowered blood calcium. There has been a tendency to explain the various types of tetany upon this basis. We have produced tetany in animals by perfusing distilled water through the peritoneal cavity (50). This tetany may be relieved by the simultaneous intravenous injection of adequate pure sodium chloride. When pure physiologic saline is perfused through the peritoneal cavity, tetany does not usually occur even though the blood calcium falls (50). It would seem from our experiments and from a study of certain morbid states, that certain forms of tetany are associated with demineralization and particularly with an extensive loss of chloride.

The frequent occurrence of lowered blood chloride in various morbid conditions and the relief of the symptomatology in certain of these conditions by the administration of sodium chloride by mouth, by hypodermoclysis, or intravenously, indicate the significance of hypochloremia. It is difficult properly to evaluate with the evidence at hand the complex physico-chemical changes which occur in the blood and tissues of the animals which we have perfused with distilled water or various other solutions. The evidence, however, which we have, both from the literature and from these briefly presented experiments leads us to reemphasize the significance of the minerals to life and a state of well being.

The evidence for the significance of calcium and its relation to parathyroid function is convincing. Likewise the interrelation between thyroid function and iodine is inescapable. The specificity of chloride is not so clear.

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Caves and Caverns.

A delightful account of the unusual caverns with which the western part of Virginia is honeycombed. An interesting and intelligible account of the geologic history of the cave regions is given, followed by descriptions of both the developed and the undeveloped caverns. The characteristics of the caverns and the nature of the bedrock are taken up in some detail. Glossary, bibliography and index are furnished, and the book is fully and beautifully illustrated. The binding and make-up are excellent, forming a volume worthy of inclusion in any library.

L. H. S.

Caverns of Virginia, by William M. McGill. xvi + 187 pp. Charlottsville; Virginia Geological Survey. $1.00 + postage (3 lbs.).

Mineral Deposits.

To those who are familiar with the earlier editions of "Mineral Deposits" no additional recommendation is necessary. To those unfamiliar with them we wish to state that here in one volume, all mineral deposits, except coal and petroleum, are well covered. After a rather careful consideration of types of mineral deposits (covering some 200 pages), there are taken up the mineral deposits of the world. We find collected together the deposits of like origin. The main divisions of Lindgren's classification are: I, Deposits produced by mechanical processes of concentration (no subdivisions); II, Deposits produced by chemical processes of concentration, with the following major subdivisions: A, in bodies of surface water; B, in bodies of rocks; and C, in magmas by processes of differentiation. These divisions contain numerous further subdivisions. In addition to the text of the volume there are abundant carefully chosen references in the form of foot-notes. Full locality and subject indexes are very useful.

WILLARD BERRY.

Mineral Deposits, by Waldemar Lindgren, 4th Ed., xviii + 934 pp. New York, The McGraw-Hill Book Co., 1933. $6.50.

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LABORATORY STUDIES OF MOUNTAIN STRUCTURES.

(A REPORT OF PROGRESS.)

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Several investigators have used the compression box type of machine for the study of mountain structures in the laboratory, but so far as I know, no one else has used a machine of such dimensions as that constructed by Stone, with the face of the thrust block at an angle other than ninety degrees to the direction of thrust (1). My first investigations were begun using a modification of this machine in order to study structures produced by thrusting, the thrust being transmitted by the advance of a thrust block the face of which was at an angle of forty-five degrees to the direction of thrust. Since starting the work it has seemed advisable to study the results obtained by the use of the unmodified machine as well as those obtained by the use of the modified machine (2).

The materials used are layers of clay to represent incompetent strata and paraffine to represent the competent strata. In the early stages of our work at Muskingum College, Stone experimented with Plaster of Paris for the competent layers, but found it too brittle and faulted rather than folded. In all my work I have used pure paraffine for the competent strata. As the paraffine layers represent the competent strata their thickness is an important factor and will be given in all cases.

In these studies the blocks to be compressed were built of two layers of clay separated by a paraffine layer and capped by another paraffine layer. An overburden of sand was piled on top to give pressure corresponding to the weight of younger strata and the block was shortened seven inches. In the earlier stages of our work various combinations of clay and paraffine

layers were used and in no case was any attempt made at uniformity of thickness of the individual paraffine layers. These layers varied from paper thin to three-sixteenths of an inch in thickness. In all cases the thrust was transmitted by a block the face of which advanced at an angle of forty-five degrees to the direction of thrust. Later experiments were tried, and are still being tried, in which uniformity of paraffine layers has been maintained. In some cases the thrust is transmitted by a block the face of which advances at an angle of forty-five degrees to the direction of thrust and in other cases the face of the block advances at ninety degrees to the direction of thrust.

Some of the experiments are here described and tentative conclusions drawn from the results. We are continuing these studies and plan to carry on field studies in connection with our laboratory experiments in the hope that we might get more definite results, but we are of the belief that some of our preliminary results and tentative conclusions may be of interest.

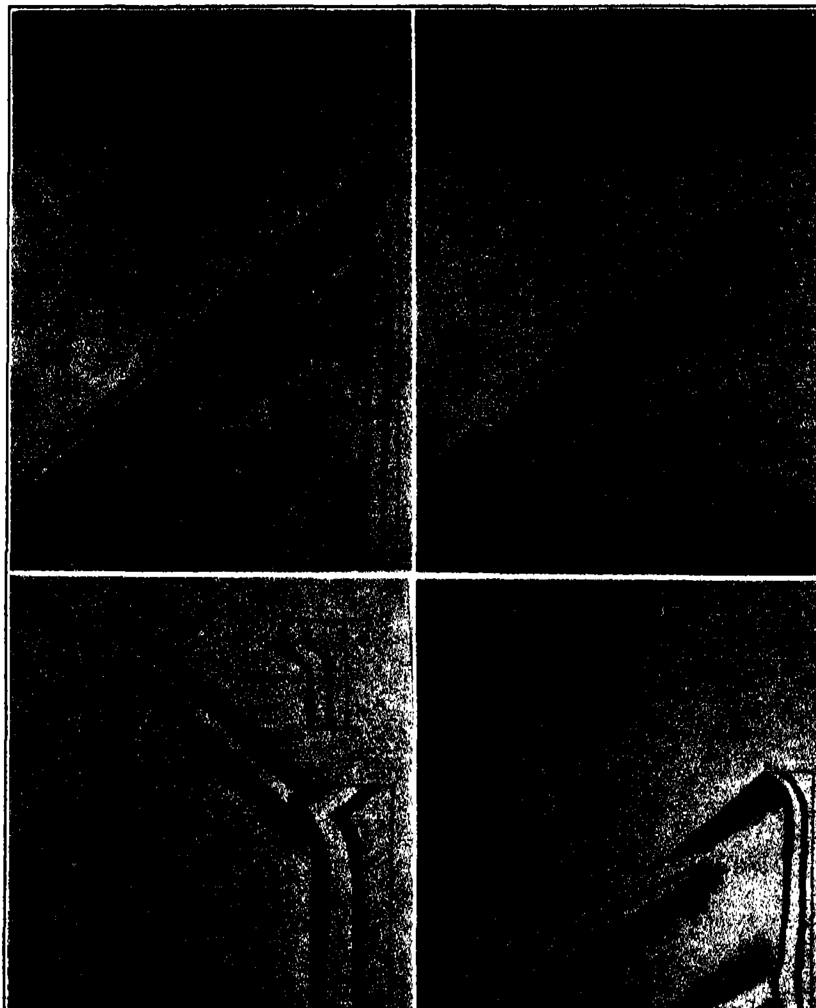
For the sake of clearness in describing the results let us suppose that the thrust comes from the east, then the side of the block opposite the thrust will be the west. Thus we can speak of the various portions of the block in terms of direction.

A block was made in which the lower paraffine layer varied from three-eighths of an inch in thickness at the south side of the block to paper thin at the north side of the block. The top layer of paraffine was of similar thickness.

On the side of the block nearest the thrust, where the paraffine was thickest, the layers folded once into an asymmetrical anticline having its steeper side next to the thrust. The crest of the anticline broke thus causing a fault to develop. On the west side of the block, where the paraffine layers were thick, the layers rode up on the confining wall. Toward the north side of the block, near the thrust, a series of small asymmetrical folds developed. This seems to indicate that the thrust was transmitted much better by the thick layers than by the thin ones.

Across the block at the west side, where the paraffine layers were thin, the top layer broke into a series of asymmetrical folds which were parallel to the face of the thrust block. It will be noted by reference to Figure 1 that these folds are slightly arcuate.

Another block was formed in which the bottom paraffine



layer was from three-sixteenths of an inch to one-quarter of an inch in thickness. The top layer varied from one-eighth of an inch to five-sixteenths of an inch in thickness, thickening toward the thrust block.

On the south-east side of the block the layers rode up on the thrust block. Farther north along the thrust block an asymmetrical anticline developed having its steeper side next the thrust block. Beginning about the place where this anticline developed a symmetrical anticline developed parallel to the face of the thrust block and at a distance from it. Near the south-west corner of the block a series of folds developed parallel to the face of the thrust block.

These results indicate that where the competent layers are thick the thrust is transmitted easily and a few larger folds result. (Figure 2.)

In another block the bottom layer of paraffine varied from one-eighth of an inch to five-sixteenths of an inch in thickness, being thinner near the thrust block. The top layer was paper thin on the west side, thickening to three-eighths of an inch at the east side.

On the east side of the block, where the paraffine layer was thickest, the layers were folded into an asymmetrical anticline the steeper side of which was to the west. At the south-east corner of the block a large asymmetrical syncline formed, the steeper side of which was away from the thrust. On the limb of the anticline near the thrust, in the top paraffine layer, a series of five small folds were formed. These folds amounted to small wrinkles on the surface of the paraffine and were due to the compression of the layer into a smaller area. Toward the north-east corner of the block, where the paraffine was thin, a series of small asymmetrical folds were formed parallel to the face of the thrust block.

Midway across the block, with one end joining the previously described anticline at a point where the anticline breaks into several folds, was a hook-shaped anticline resembling a large reversed J. This developed only on the surface layer. The steeper side of this fold was toward the east. The peculiar shape of the fold was probably due to the force resultant of the several forces acting—the active thrust and the stationary blocks. From the barb of the hook-like anticline there extended a small asymmetrical anticline parallel to the face of the thrust block. (Figure 3.)

A block in which the basal paraffine layer varied from three-sixteenths of an inch to paper thin and the top layer of which varied from one-sixteenth of an inch to paper thin was subjected to a thrust similar to that to which the other blocks were subjected.

Along the east side of the block the layers folded upward riding up on the thrust block. The fold was broken on the flank by a series of smaller folds having the steeper side toward the west. Because the competent layers were too thin to transmit the thrust for any great distance the folds broke into a number of smaller ones. Near the south-east side of the block a series of small folds developed in the top layer. These folds made an angle with the face of the thrust block joining the upthrust portion about fourteen inches from the south side of the block. About half way across the block, in the top layer, there was a series of parallel folds almost parallel to the face of the thrust block but making a slight angle with it. These folds were low and small. They parallel the face of the thrust block for a short distance then swing around parallel to the west wall of the machine. Note that this fold curves. (Figure 4.) The bottom layer of paraffine was unaffected except by slight thickening at the ends of the block and faulting near the thrust block.

Another block was deformed in a similar way. This block was built as the others but the bottom paraffine layer was paper thin and the top paraffine layer varied from a quarter to a half inch in thickness. (Figure 5.)

Near each end of the thrust block the thick paraffine layer rode up on the block. At a distance of about five inches from the thrust block, measured along the south edge, a large, gentle fold developed at an angle to the face of the thrust block and meeting it about eighteen inches from the south-east corner of the block. Across the block near the west wall an asymmetrical anticline developed having the steeper side away from the thrust. The paraffine layer rode up on the west wall. The bottom paraffine layer had a few small folds and faults not coincident with those above. This experiment shows that the thrust is best transmitted by the thicker layers and that folds are fewer in number and of greater magnitude.

As has already been suggested some of our later experiments have been carried on using both the modified and unmodified machine with special effort being made to maintain uniformity


5

of thickness of the individual paraffine layers. We are at present engaged in such studies varying the thickness of the paraffine layers and trying various combinations in order to find, if possible, the mathematical relationship between thickness of competent layers and number and magnitude of folds.

In one of these experiments the paraffine layers were five-sixteenths of an inch in thickness. The block was shortened eight inches by the advance of a thrust block the face of which advanced at an angle of ninety degrees to the direction of thrust.

The layers rode up on the thrust block. An arcuate anticline formed three inches from the thrust block along the south side and nine and one-half inches from the thrust block at the north side. Along the west wall a small fold formed having its steeper side toward the west. All these folds were greatly faulted. One fault developed along the crest of the anticline and numerous others at right angles down the limbs of the folds. (Figure 6.)

A number of arcuate folds were formed both in blocks in which no effort was made to maintain uniformity of competent layers as well as in blocks where uniformity was maintained. They formed in blocks which were compressed in the modified machine and those which were compressed in the unmodified machine.

The experiments here described are a few of those performed but they serve to illustrate some of the results from which the following tentative conclusions have been drawn. There seems to be a relationship between the thickness of the competent layers and the number and magnitude of the folds. Exactly what this relationship is we cannot state with mathematical accuracy, but our results seem to indicate that where the competent layers are thick a few large folds are formed and where the competent layers are thin numerous small folds develop. At present we are carrying on investigations using competent layers of uniform thickness in the hope of discovering the mathematical relationship between the thickness of the competent layers and the number and magnitude of the folds.

These experiments also show that even though the top layers are deformed the bottom layers do not necessarily deform in a similar manner but may find relief by thickening. This may be due to the additional weight of the strata above or the fact that the lower layers may be in the zone of flowage.

The factors influencing the character, location and magnitude of folds are therefore:

1. Thickness and competency of the layers involved.
2. The forces or combination of forces involved in producing the folds.
3. The overburden.

Unfortunately, studies of this sort are suggestive rather than conclusive. As Stone suggested to the Geology section at the 1930 meeting of the Ohio Academy of Science, we cannot reproduce field conditions to scale in the laboratory because field investigators have failed to give us the needed data as to crushing and tensil strengths of the rocks involved in such structures. If we had such data we might reproduce on a small scale observed geologic structures and arrive at some conclusions as to their mode of origin.

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Spectroscopy.

This book is highly recommended to those who wish to have, in an interesting and convenient form, a discussion of the apparatus, technique and data involved in the study of Spectroscopy. The book fills a long felt need for an introductory text on this subject which might be easily understood by scientists in other fields (particularly in Analytical, Organic and Bio-Chemistry). The author suggests method of procedure together with examples of data and their interpretation. There is an absence of a suitable bibliography; and an overemphasis of the author's personal contributions detract slightly from the volume.

—WALLACE R. BRODE.

Spectroscopy, by S. Judd Lewis. 91 pp. London, Blackie and Son, Ltd., 1933.

Petroleum.

Here are brought together the results of five years research carried on at various places in the United States upon material collected from all over the world. There are dealt with in the various chapters the following major subjects: collection and preparation of samples; measurement of organic content; distillation tests; texture; calcium carbonate content; relation of organic matter to environment; detailed analyses of organic constituents of sediment; change in organic content with depth; comparison of past and recent sediments; and theoretical considerations. It is a definite contribution to the understanding of the possible origin of the source beds of petroleum.—WILLARD BERRY.

Origin and Environment of Source Sediments of Petroleum, by P. D. Trask, assisted by H. E. Hammar and C. C. Wu. xv+323 pp. Houston, Gulf Publishing Co., 1932. $6.00.

PRELIMINARY STUDY OF THE RELATION BETWEEN THERMAL EMISSIVITY AND PLANT TEMPERATURES.*

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Whenever a plant leaf is exposed to radiant energy from a source such as the sun this energy has three modes of dissipation: (1) reflection from the surface of the leaf, (2) absorption by the leaf, (3) transmission by the leaf. The quantitative value of the first varies with the nature of the receiving surface and the wavelength of the incident radiation. The value of the second varies with the nature and thickness of the absorbing tissue and the wavelength and intensity of the radiation. The amount of energy transmitted depends upon the wavelength of the radiation, the transparency and diathermancy of the leaf tissue. Of the three named possibilities of energy dispersal the second only is capable of raising the temperature of the leaf tissue and is the subject of investigation in these experiments.

In general, the leaf tissue will absorb solar energy of the period to excite the molecular vibration within the tissue concerned. The energy absorbed is mostly in the form of longer waves many of which are in the visible spectrum. These waves suffer a degradation of energy content and are emitted from the tissue as waves of a lower refrangibility.

The energy absorbed by a leaf may be dissipated in the following ways:

1. Thermal emission (radiation and conduction to the air).
2. Conduction to internal tissue of lower temperature.
3. Transpiration.
4. Photochemical reactions (photosynthesis and others).

Respiration, an exothermic reaction, is also taking place and needs to be evaluated.

RELATIVE IMPORTANCE OF DISPERSAL METHODS.

Investigations have shown the thermal unimportance of respiration and photosynthesis in considering plant temperatures. Miller (5) in a review of the literature, says the values for the percent of incident radiation used in photosynthesis range from .5% to 7.7%. However, the more recent experi-

*Papers from the Department of Botany, The Ohio State University, No. 317.

ments, Miller (6); Putter, as quoted by Spoehr (9); and Transeau (10) place the amount at less than 4%. The latter has calculated his results for corn on the basis of the total available energy per acre over a 100-day growing season in the vicinity of central Illinois. He also found that of the total available energy, only .5% was returned to the environment by respiration. Brown and Escombe (1) say that a respiring *Liriodendron tulipifera* leaf comes into thermal equilibrium with its surroundings at .019° C. In the following experiments the thermal exchanges of respiration and photochemical reactions have been neglected as insignificant.

The dissipation of heat energy by conduction to internal tissue of lower temperature has no significance in the cases where the substance is partially diathermanous or is sufficiently thin to become practically uniformly heated throughout. The latter is the case in all of the following experiments.

The poor thermal conductivity of succulent tissue may be significant in the prevention of killing by heat or frost of desert cacti which are exposed for a few hours to extreme temperature conditions. Such may be the case in the larger succulents such as *Carnegia gigantea* under conditions of intense insolation. Conduction through tissue of high specific heat and low diathermancy must be responsible for part of the cooling of the surface. A rather steep gradient of temperature is probably maintained between the internal and external tissues.

Transpiration has long been considered one of the most important methods of energy dispersal by the leaf tissue. Brown and Escombe (1) working with *Helianthus annuus*, concluded that transpiration accounted for 80% of dispersal of available energy and therefore considered this process very important as a means of energy dissipation. Shull* (8)

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*Shull gives figures part of which were taken from the work of Brown and Escombe, in which the incident radiation is .8 cal. per sq. cm. per min.; the coefficient of absorption is 65%; the mass beneath a sq. cm. of leaf surface is .02 gms. and the specific heat is .879. With these figures, and assuming no energy dispersal he calculates the rate of temperature rise of the leaf to be 29.6 degrees per min. But Brown and Escombe also say that a moderate rate of thermal emission is .014 cal. per min. per sq. cm. of leaf surface for each degree temperature difference.

Using these figures we see:

$$\frac{.8 \times .65}{2 \times .014} = 18.5 \text{ C.}^\circ$$

Thus the leaf would come into thermal equilibrium with its environment at a temperature 18.5 C.° above the environment and the rate of temperature rise equal to 29.6 C.° per min. holds at no time except when there is no temperature difference between the leaf and the air.

said, "There is no doubt that transpiration is vitally necessary, and that its chief function is energy dispersal."

Clum (3) has performed an exhaustive series of experiments to determine the cooling power of transpiration. As a result of his investigations, he concludes, "The review of the literature shows that the temperature of plant tissues is usually higher than that of the air in bright sunlight, but is subject to wide and rapid fluctuations. From the available evidence, however, the cooling effect of transpiration seldom exceeds 2 or 3 C. degrees."

Miller and Saunders (7) made over one thousand determinations of leaf temperatures of soy beans, corn, sorghum, cowpeas and alfalfa growing under field conditions in Kansas. They found no significant difference between air and leaf temperatures. They also found that the temperature of wilted leaves above that of turgid leaves in sunlight varied from 2 to 6 C. degrees.

As a result of these and other similar investigations, showing that at best transpiration could account for only a few degrees of cooling in leaf tissue, and since the range of temperature differences used varied from 3 to 30 C. °, the temperature effects of transpiration have been neglected in these experiments.

McDougal (4) using a clinical thermometer thrust into the tissue of a prickly pear cactus found that it attained a temperature of 31° F. above air temperature, that elongation continued even at 137° F., and that heating to 144° F. would not permanently injure the plant.

Clum (3) found that the presence of a large water content seemed to make little difference in the rapidity of temperature fluctuations, noting that the fresh leaf fluctuated as rapidly and over as wide range as the dried one. My own results do not agree with this as I found small but consistently greater emissivity values for dried leaves than for fresh ones of higher water content.

Brown and Wilson (2) have investigated the effects of thermal emission on plant temperatures. Proceeding on the assumption that a leaf maintained at a temperature above that of the surrounding air will lose heat at the same rate that a leaf maintained the same number of degrees below air temperature will gain heat, they were enabled, by the differential transpiration method to determine the rate of emission in terms of calories per unit of surface and time, and for a

one-degree temperature difference between the leaf and its surroundings.

Although these investigations involved a range of only two degrees, from 17° to 19° C., these authors conclude that, "The variation of the coefficient of emissivity with temperature can safely be neglected for any range of temperature to which the leaf may be subjected under natural conditions." The experiment was carried on with similar leaves from four different species and the results agreed very closely.

Clum (3), however, agrees with other investigators, that the leaf temperatures calculated from the emissivity formula of Brown and Wilson are consistently below those temperatures which have been observed by means of the thermocouple. The reason for this may lie in the method of determining leaf temperatures which Brown and Wilson used. The temperatures they recorded with their platinum resistance thermometers in contact with the leaf surface could at best record only the temperature of that surface and actually must have been somewhat influenced by the higher temperature of the surrounding air.

Even though the differential method was used, the thermometer which was at a lower temperature would be more influenced by the higher air temperature. Thus the heat which flowed into the plant per degree temperature difference was calculated to be greater than it probably actually was, with a consequent too great value for the emissivity factor.

Clum also notes that, ". . . the temperature of the leaf is so influenced by the intensity of the light that one can tell very little about the transpiration rate from the temperature and emissivity as calculated for leaves in the dark." That this is a legitimate criticism can be seen at once by noting the absurdity of the result obtained under certain conditions by the use of the formula which Brown and Wilson (2) proposed, viz.,

$$E = Qh/(\theta - \theta')$$

where E is emissivity, Q is grams of water lost, h is the latent heat of vaporization of water, and $(\theta - \theta')$ is the temperature difference between the leaf and air. One can readily conceive of a case where the radiant energy absorbed by a leaf would be just sufficient to carry on transpiration. Thus the temperature difference would be zero and emissivity would take on an infinite value.

APPARATUS.

The thermocouple set-up consisted of a mirror galvanometer used in conjunction with two junctions of copper and constantin wire. B&S Gauge 30 constantin wire and B&S Gauge 40 copper wire were soldered to form each junction. The constantin was introduced through a glass tube which had been drawn out to capillary size and then broken off back just far enough to permit a rather snug fit of the wire. This wire was allowed to protrude about two centimeters from the end of the glass capillary and copper wire was soldered to the constantin. The glass tube was carefully advanced upon the constantin until it just touched the soldered portion of the junction, the copper wire remaining on the outside. A piece of B&S Gauge 22 copper wire of sufficient length to reach a single pole switch was soldered to the No. 40 copper about five centimeters from the junction.

Another piece of tubing whose internal diameter was sufficient to hold the original tubing and the No. 22 copper wire was also drawn out to a fine capillary. This tube was then placed over the junction, enclosing the smaller tube, all of the No. 40 copper and about two centimeters of the end of the No. 22 copper wire. These were held firmly in position within the tube by means of sealing wax having a high melting point. None of the wax, however, was permitted to come into contact with the junction. The external tube was broken off so that both tubes ended at the junction, which was allowed to protrude about 1 mm. beyond the end of the glass. Construction of the couple with this fine wire permitted a junction to be used whose size caused a minimum of injury to the tissue into which it was inserted.

The galvanometer was the Leeds and Northrup type 2285-X.

As most of the thermal measurements were to be between 20° and 50° C., it was desired to have the reference junction somewhere within this range, and a method of keeping it at constant temperature. This was accomplished by allowing water to come into equilibrium with a 37.5° C. incubator. This water was then poured into a thermos bottle which had also been in the incubator for several hours and sealed with a single hole rubber stopper through which the reference junction, similar in construction to the one described above, was placed. This junction then remained within the incubator during the

course of the experiments. The actual temperature of this junction was determined by a zero galvanometer reading. The thermocouple was then calibrated, using a large standardized mercury thermometer graduated to 0.1° C. so that one cm. on the galvanometer scale corresponded to approximately one degree. Temperatures accurate to 0.1° C. could easily be read.

The heating element used in some of the experiments was the Rodale Straight Type Heating Element, similar to that used in many reflecting heaters. An ordinary metal reflecting lamp shade was placed around the element.

EXPERIMENTAL PROCEDURE.

According to definition, emissivity is the rate of thermal emission, or the number of calories lost per unit of time from a square centimeter of surface of a body for each degree of temperature difference between the body and its surroundings. In order then to know the corresponding temperatures to which the body will be subjected, it is necessary to know the mass, specific heat, and area of surface of that body.

The following experiments are, however, based upon rates of temperature loss, and the rate of cooling is expressed in terms of degrees lost per minute for each degree difference in temperature. A determination of rates of temperature loss provides a more significant as well as more accurate means of making comparison between leaf tissues from different plant species. It has the added experimental advantage that determinations can be made upon the tissue concerned while attached to the plant.

On all the plants the rate of thermal emission was calculated by observing the temperatures at equal intervals of time of a plant leaf which was cooling to room temperature, or rising from room temperature as a result of being placed in a constant temperature oven or exposed to radiation from the heating element. The results agree quite closely showing that absorption and emission are practically the same for any given temperature difference.

The rate of temperature loss for any temperature was found as follows: The leaf was heated by means of incident radiation from the heater element. The latter was mounted on the top of a revolving stool so that it could quickly be removed from the region of the plant by a half revolution of the stool top.

When the desired temperature difference was attained the

heater was removed and the leaf began to drop in temperature. Readings on the galvanometer were taken at 10-second intervals until the leaf had come into thermal equilibrium with its environment. The average temperature for two successive readings was found and subtracted from the equilibrium temperature. This was called the average temperature difference. The difference between successive readings gave the temperature drop during that 10-second interval. When multiplied by 6, this gave the rate of temperature loss per minute for the average temperature difference already determined.

A graph was then constructed using the average temperature differences as abscissae and the rates of temperature loss as ordinates. A comparison of the curves of a number of leaves of the same type, i. e., of the same species and maturity, from different plants not only showed very close agreement in rates of temperature loss, but above a temperature difference of 3 C.°, the curve was practically a straight line.

A straight line was then fitted to these data by the method of least squares. The result was a linear equation of the form

$$d\theta_t/dt = K\theta_t + b$$

where $d\theta_t/dt$ is the rate of temperature loss at time t, and θ_t is the temperature difference at time t. Since we know the rate of cooling must be zero when there is no temperature difference the value of 'b' is at once fixed at zero.

Therefore, the rate of cooling for any temperature difference above 3 C.° is proportional to the temperature difference multiplied by a constant 'K' which varies with the nature of the tissue.

DERIVATION OF THE GENERAL COOLING LAW.

It is desirable to investigate the general law of cooling which these tissues were found to follow.

Let θ_t be the temperature difference t seconds after leaf begins to cool.

Let $d\theta_t/dt$ be the rate of temperature loss at time t.

Let K be the constant whose value we seek.

Then the law of cooling is

$$d\theta_t/dt = -K\theta_t$$

or

$$\int d\theta_t/\theta_t = -K\int dt$$

whence

$$\log_e \theta_t = -Kt + \log_e c$$

where e is the base of the natural logarithms and $\log_e c$ is the constant of integration.
Then

$$\theta_t = c\,e^{-Kt}$$

We know that for 't' equal to zero

$$\theta_0 = c$$

The constant 'c' is therefore determined to be numerically equal to the initial temperature difference, θ_0.

The rate of cooling after any time t has elapsed can be found by substituting the number of minutes for t in the following formula.

$$R_t = d\theta_t/dt = -\theta_0 K e^{-Kt}$$

A comparison of cooling rates after any time interval t, for the same or different leaf tissues can then be made even if the initial temperature differences be not the same. In such a case the constant θ_0 is made to correspond to the initial temperature differences for the respective tissues.

It remains then, to determine 'K' for tissues of varying degrees of succulence and water content.

DETERMINATION OF 'K' FOR FRESH LIRIODENDRON LEAVES.

Liriodendron tulipifera seedlings, three years of age, were transplanted from the garden into the greenhouse. They ranged in height from 1½ to 4 feet. Only mature leaves were used in the experiments. The junction of the couple was inserted into the mesophyll near the midrib. The insertion was placed on the under side of the leaf and care was taken to prevent its penetration into the upper epidermis upon which the radiation from the heating element was received.

The following series of experiments was performed. A different attached and mature leaf was used in each experiment. Leaves from three trees were used. Fourteen experiments were made in all.

1. Heated with element to 36° and allowed to cool to 22° C.
2. Heated with element to 35° and allowed to cool to 21° C.
3. Heated with element to 43° and allowed to cool to 24° C.
4. Heated with element to 29° and allowed to cool to 21° C.
5. Heated with element to 33° and allowed to cool to 22° C.
6. The heater was turned upon a leaf at about room temperature and the leaf was allowed to heat until the galvanometer showed an approximately uniform rate of rise. Readings at ten second intervals were then taken.

a. Heating from 33° to 44° C.
b. Heating from 31° to 38° C.

From these date the average value of 'K' and the probable error of the mean were found to be

$$K = 2.1 \pm .11$$

The equation of cooling for *Liriodendron tulipiera* is

$$d\theta_t/dt = -2.1\ \theta_t$$

and the temperature difference after any number of minutes 't' is

$$\theta_t = \theta_o\ e^{-2.1t}$$

where 'θ_o' is the initial temperature difference between the leaf and the air.

DETERMINATION OF 'K' FOR MESEMBRYANTHEMUM.

The plant used was *Mesembryanthemum crystallinum*. The leaves were in a turgid healthy condition. The thermocouple junction was inserted into the mesophyll so that radiation from the heater was allowed to fall upon the leaf on the side opposite that in which the insertion was made.

In these experiments the leaves were heated to about 40° C. and allowed to cool to equilibrium at 22° C. Temperature readings were taken each ten seconds during the cooling period. Four experiments were made. A different leaf from the same plant was used in each experiment. The average value of 'K' and the probable error of the mean are:

$$K = .45 \pm .02$$

The equation of cooling for *Mesembryanthemum* is

$$d\theta_t/dt = -.45\ \theta_t$$

and the temperature difference after any number of minutes 't' is

$$\theta_t = \theta_o\ e^{-.45t}$$

where 'θ_o' is the initial temperature difference between the leaf and air.

DETERMINATION OF 'K' FOR BYROPHYLLUM CALYCINUM.

The *Bryophyllum calycinum* leaves used were from plants which had reached maturity in the greenhouse. Four types of experiments were made, each with a different leaf.

1. Heated in incubator to 54° C. and allowed to cool to 24° C. in air. These leaves were detached from the plant.
2. Heated by heater element to 42° C. and allowed to cool to 24° C. The leaves were attached to the plant.
3. Detached leaf at 23° C. was placed in a 58° C. incubator and the rate of temperature rise of the leaf was taken at ten second intervals.
4. Attached leaf heated by element until uniform rate of rise was observed on the galvanometer. Initial recorded temperature 29° C., final temperature 45° C.

Eight experiments were made. The results of these were averaged and 'K' for fresh *Bryophyllum calycinum* was calculated from the formula. The average value of 'K' and the probable error of the mean were found to be

$$K = .38 \pm .02$$

The equation of cooling for *Bryophyllum calycinum* is

$$d\theta_t/dt = -.38\,\theta_t$$

and the temperature difference after any number of minutes 't' is

$$\theta_t = \theta_0\, e^{-.38t}$$

where 'θ_0' is the initial temperature difference between the leaf and air.

DETERMINATION OF 'K' FOR ECHEVERIA WEINBERGIA.

In these experiments mature and turgid leaves of *Echeveria weinbergia* were used. The junction was inserted into the mesophyll so that it lay about midway between the epidermal tissues. The leaf was heated to 48° C. by means of the heater element and allowed to cool to equilibrium temperature. Temperature readings were taken each ten seconds during the period of cooling. Six experiments were made, each with a different leaf on the same plant. The value of 'K' and the probable error of the mean were then calculated to be

$$K = .08 \pm .004$$

The equation of cooling for *Echeveria weinbergia* is

$$d\theta_t/dt = -.08\,\theta_t$$

and the temperature difference after any number of minutes 't' is

$$\theta_t = \theta_0\, e^{-.08t}$$

where 'θ_0' is the initial temperature difference between the leaf and air.

DETERMINATION OF 'K' FOR CEREUS.

The *Cereus* used was a four-ribbed rooted cutting, six inches high, which appeared in healthy condition. The thermocouple was inserted into the stem until the junction lay about midway between the epidermal tissues. The plant and junction were placed in the incubator whose temperature was 55° C., and the temperatures were recorded at intervals of one minute until equilibrium was reached. The plant was then taken from the incubator and allowed to cool in air and temperature readings were again taken each minute. From the series of eight experiments, four of the heating and four of the cooling type, the value of 'K' and the probable error of the mean were computed to be

$$K = .05 \pm .002$$

The equation of cooling for *Cereus* is

$$d\theta_t/dt = -.05\ \theta_t$$

and the temperature difference after any number of minutes 't' is

$$\theta_t = \theta_o\, e^{-.05t}$$

where 'θ_o' is the initial temperature difference between the stem and air.

EFFECT OF DESICCATION ON THE CONSTANT 'K.'

Having obtained the value of 'K' for several normal tissues, the effect of drying out on the rate of thermal emission could be put upon a quantitative basis.

Accordingly the following experiments were performed with *Liriodendron* and *Bryophyllum* leaves.

The junction was inserted into a leaf of *Liriodendron tulipifera* attached to the plant. Radiation from the heater element was then thrown upon the upper surface until a temperature of equilibrium at 40° C. was reached. The leaf was subjected to this temperature for one hour. At the end of this time several brown spots had appeared and the margin had begun to curl slightly. The heater was removed and temperatures of cooling were recorded at ten second intervals. Four experiments were made. The average value of 'K' was computed and found to be 2.5. This is about 19% above the value found for fresh leaves of the same species.

A leaf of *Bryophyllum calycinum*, attached to the plant, was heated by the heater element to 50° C. and maintained at that temperature for 90 minutes. One experiment was made. 'K' was calculated to be .45. This value is 18% greater than for the fresh leaf.

Another leaf of *Bryophyllum calycinum* was detached from the plant and suspended within a constant temperature oven at 55° C. for 26 hours. It was then removed and the temperature record of cooling was kept as before. Two experiments were made. The value of 'K' in this case was found to be .69. This is 80% above the value found for fresh leaves of the same species.

TEMPERATURE EFFECTS OF RESPIRATION AFTER INJURY.

Since injury to a tissue sometimes results in increased respiration it was desired to find the temperature effects of this increase caused by insertions of the thermocouple.

Three leaves of *Bryophyllum calycinum* each of which had been punctured in several places with the thermocouple were suspended near the top of a quart size thermos bottle. The thermocouple was inserted into the mesophyll of the second leaf. The bottle was filled with water at room temperature within three or four centimeters of the leaves and was then closed with a rubber stopper. This was done to saturate the atmosphere in which the leaves were suspended and thereby reduce heat losses by transpiration.

At the end of twenty minutes, no temperature change was noted. The temperature then began to rise slowly and at the end of four hours had reached a maximum of 1.3 C.° above air temperature.

However, of the experiments performed to determine the values of 'K,' none lasted more than one hour and twenty minutes, only one insertion of the thermocouple was made and there was no confinement permitting the accumulation of heat.

Thus, it is seen that under conditions which were more favorable to show temperature effects of respiration after injury than those obtaining during the determination of 'K,' no significant thermal effects were noted. The increased temperature effects of such respiration have therefore been neglected as insignificant.

EFFECT OF VASELINE UPON THERMAL EMISSIVITY.

Leaves of *Liriodendron tulipifera* and *Bryophyllum calycinum* were coated with a thin layer of vaseline over both surfaces and a redetermination of 'K' was made. In *Liriodendron* the layer of vaseline caused an 18% drop in the emissivity constant, while the constant for *Bryophyllum* was reduced by 13%.

In order to find the magnitude of the effect due to vaseline alone it was necessary to apply it to a plant tissue having a minimum of water loss. Therefore, the four ribbed cutting of *Cereus*, whose emissivity constant 'K' had already been determined to be .05 was entirely coated with vaseline and the value of 'K' again found. A decrease of 11% was noted.

Since the water losses in *Cereus* over the period of the experiment (one hour and twenty minutes) were insignificant, the 11% decrease in the value of 'K' must be due to the presence of the vaseline itself. If this be true, then complete prevention of transpiration causes a 2% drop in emissivity in *Bryophyllum* and 7% in *Liriodendron*. Thus the small portion of the value of 'K' which is due to transpiration is evident.

DISCUSSION.

It has been shown by these experiments what many recent investigators have suspected, viz., that the physical thermal properties exhibited by leaf tissue provide an adequate means of dispersal for excess radiant energy.

Even though Clum found that transpiration, at best, was responsible for only two or three degrees of cooling, while Transeau (10) computed 45% of the energy available per acre to be used in this work of evaporation, these results are not at all irreconcilable. The latter calculated his results for an acre of corn, the same plant which Miller and Saunders, in over a thousand determinations, found did not differ materially in temperature from that of the air. Because such a large percentage of energy was used in transpiration, it does not mean that the latter function was the mechanism which prevented the overheating of the tissue. It simply means that the rate and intensity of the incident radiation was just the correct amount to be almost entirely absorbed by the vaporization which was taking place. Had the intensity of the radiation been materially increased we would find that the physical thermal properties of the tissue and not transpiration would

prevent overheating. In the latter case, although transpiration would probably be slightly increased, it would consume a much smaller percentage of the available energy than in the situation noted above. It is, therefore, quite impossible to calculate the relative importance of transpiration as a cooling agent by observing the percentage of the available energy which it consumes.

In all of these experiments the rate of temperature loss only was determined.

But $dQ_t/dt = d\theta_t/dt \times a$

where dQ_t/dt is the rate of heat loss in calories at time 't'

$d\theta_t/dt$ is the rate of temperature loss in degrees at time 't'

a is a constant whose value is the product of the mass and specific heat of the tissue concerned.

If we wish to compare the rates of temperature loss of two types of tissues of known cooling rates, we have

$$\frac{d\theta_t'/dt}{d\theta_t/dt} = \frac{-K'\theta_t}{-K\,\theta_t} = \frac{K'}{K}$$

and the ratio becomes that of the cooling constants.

Cereus K = .05
Bryophyllum K = .38
Liriodendron K = 2.10

Thus *Bryophyllum* cools 7.6 times as fast as *Cereus*.

Moreover *Liriodendron* cools 5.5 times as rapidly as *Bryophyllum* and 42 times as fast as *Cereus*.

As an example of how the rate of temperature loss may be used to determine the absolute emissivity the following calculations for *Liriodendron tulipifera* were made.

K = 2.1
Mass of Leaf = .79 gms.
Total area of leaf = 70. sq. cms. × 2
= 140. sq. cms.

Using Brown and Escombe's value of .879 for the specific heat of the leaf, we are able to find the absolute emissivity per sq. cm. per unit temperature difference.

Thus

$$\frac{2.1 \times .79 \times .879}{140} = \text{.010 cal. per sq. cm. per min. per degree temperature difference.}$$

Brown and Wilson's calculations for this same species by the differential transpiration method gave the result .012 cal. per sq. cm. per min. per degree difference in temperature.

We can now calculate at what temperature the leaf would come into thermal equilibrium with its surroundings under the same still air conditions as were used to find 'K.'

The equilibrium temperature when the leaf is receiving on one surface incident radiation at the rate of .5 cal. per sq. cm. per minute and transpiring at the normal rate can be computed. Assuming the coefficient of absorption of the leaf to be .65, the equilibrium temperature would be.

$$\frac{.65 \times .5}{2 \times .010} = \begin{matrix}16.3 \text{ C. }^\circ \text{ above air} \\ \text{temperature.}\end{matrix}$$

Clum, working with *Fuchsia speciosa*, *Phaseolus vulgaris*, *Brassica oleracea* and *Syringa vulgaris*, observed maximum temperatures to be 13° C. and 16° C. for the open field and greenhouse, respectively.

One fact appeared during the course of the experiments which appeared difficult to explain. At 3 C. ° temperature difference the value of 'K' fell off rather sharply and consistently in *Liriodendron* and only slightly less marked in *Bryophyllum*.

The average value of 'K' for *Liriodendron* over 13 trials was 1.8 as against 2.1 for temperature differences greater than 3 C.° In *Bryophyllum*, for eight trials, the drop in emissivity was noted from .38 to .35. No such drop appeared in four trials with *Cereus*.

There are two possible explanations:

1. A greater proportion of temperature loss is due to transpiration under a 3 C.° temperature difference and less to the physical properties of the leaf The former method of energy dispersal disposes of the heat less rapidly than the latter, with a consequent drop in the rate of temperature loss, and also in 'K.'

2. At lower temperature differences under still air conditions the removal of air from around the cooling tissue by convection currents is much less rapid and a decreased rate of cooling results.

SUMMARY.

1. Thermal emissivity and not transpiration is the agent which prevents overheating of plant tissue.

2. The proportion of available energy absorbed in transpiration gives no indication of its cooling value.

3. For temperature differences greater than 3 C.° the rate of cooling of a plant tissue is a linear function of the temperature difference between the leaf and air, under still air conditions.

4. The effect of desiccation is to increase the emissivity of the tissue.

5. A method is described for finding the thermal emissivity of the tissue by observing its rate of cooling under known conditions.

6. The rates of temperature loss and constant 'K' have been calculated for *Liriodendron tulipifera*, *Bryophyllum calycinum*, *Mesembryanthemum crystallinum*, *Echeveria weinbergia*, and *Cereus*.

7. A comparison of the constants of proportionality between rates of cooling for any two plants gives a comparison of the rates themselves. Thus the plants can be grouped according to their respective emissivities.

8. The thermal emissivity of *Liriodendron tulipifera* was determined and compared to the value found by Brown and Wilson for this species. The result was 17% less than that of Brown and Wilson.

9. A formula was derived for finding temperature of a tissue of known emissivity and initial temperature, after the interval of any number of minutes. Conversely the length of time required for the tissue to fall in temperature any number of degrees can also be determined from the same formula.

10. The presence of vaseline upon the surface of a plant tissue decreases, *per se*, the emissivity of that surface.

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AVIAN TUBERCULOSIS IN FREE WILD BIRDS.

LOUIS B. KALTER, H. FEDERIGHI AND O. L. INMAN
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The occurrence of avian tuberculosis in domestic birds and wild birds in captivity has been reported and reviewed frequently [Hastings and Halpin (1913), Van Es and Schalk (1914), Gallagher (1921), and Mitchell and Duthie (1929)].

Van Es and Schalk (1914) "observed a well-marked case of tuberculosis in a sparrow which had access to an infected poultry yard." They cite a tuberculous sparrow mentioned by Metschnikoff (1888), but it is not clear whether this was a bird in captivity. In 1929 Mitchell and Duthie reported avian tuberculosis in *Corvus b. brachyrhynchos*, from western Ontario where the birds were dying in large numbers. In a private communication (1933), Dr. Mitchell very generously communicated the following material: "In addition to this preliminary report considerable work has been carried out which has never been published. We examined over six hundred common crows. . . . Approximately 8% of the crows captured were tuberculous. . . . All . . . were wild. With one exception all cases were closely associated with the usual avian type of tuberculosis."

The writers wish to report a case of tuberculosis, apparently of the avian type, in a male eastern sparrow hawk (*Falco s. sparverius*) which was found dead, but still warm, on a street in Yellow Springs, Ohio, on January 20, 1933.

Upon dissection the breast muscles were seen to be greatly emaciated allowing the ridge of the carina to stand out prominently. The gizzard was empty and no fat was seen on the hawk's body. Imbedded in the lobes of the liver were many yellowish tubercles approximately 1.5 × 2.5–3.0 mm. in dimension. Smaller tubercles were found on the mesentries holding the convolutions of the intestine while on the intestine there were large flat irregular tubercles which reached diameters of 4.5 mm.

The lesions or tubercles from the liver approximated Pfander's second type of nodules (Van Es and Schalk, 1914). Sections of the necrotic liver material stained by the Ziehl-Neelsen method revealed acid-fast bacilli. Large numbers of

bacilli were in and surrounding the capsule but very few were in the central hyaline area.

Our results were checked through the kindness of Dr. Charles B. Morrey, Ohio State University, who wrote: "Dr. Fred Speer has stained material from the specimen of liver. . . . He finds acid-fast bacilli and there is no doubt that it is Avian Tuberculosis."

On the day after the diseased hawk was found, potato slants were streaked with material from a crushed liver tubercle. After one month smears taken from five cultures revealed only a small number of acid-fast bacilli on one slant. Subcultures were made in glycerin broth; complete results are not yet available.

Where this sparrow hawk contracted tuberculosis is problematical, possibly from the infected remains of domestic fowl disposed of carelessly or accidentally killed by automobile or interurban car along a nearby highway. Another possibility is that the disease might have been picked up from a wild or "domestic" mouse (Van Es and Schalk, 1914).

With increased investigation avian tuberculosis will probably be found in many other families of wild birds. Indicative of this is a statement in a letter from Milton B. Trautman, Bureau of Scientific Research, Ohio Conservation Division: "In the examination of some 1,000 wild birds, . . . I have found very little of what I considered tuberculosis, . . . In several cases I have seen these yellow lesions or tubercles in the mesentries and liver and in one or two cases have also found tubercles on the kidneys."

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Scientific Research.

It is said that a depression may end with the consumption of existing perishable goods, but prosperity is dependent on new developments which come only through research and its application. This volume weaves the threads of romance and adventure into the story of research, and makes of it a most fascinating tale. Each student intending to enter a life of experimental work should be required to read it.—L. H. S.

The Romance of Research, by L. V. Redman and A. V. H. Mory. x+149 pp. Baltimore, The Williams and Wilkins Co., 1933.

A UNIQUE RAISED BOG AT URBANA, OHIO.*

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Ohio State University.

Located just north of the Champaign County Fair Grounds at Urbana, Ohio, is a unique dome-shaped bog, covered with shrubby vegetation for the most part, in which the center is raised at least ten feet above the margins. An old road crosses the bog. I have been told that it was once the main thorofare from Urbana to Columbus. Horses and wagons passed over it, I suppose, the drivers never realizing that a mat of fibrous roots less than one foot thick was all that held them over a body of water twelve feet in depth.

Raised bogs, called "high moors" and "Hochmoore" in foreign literature, have long been known throughout Europe. N. S. Shaler is credited by Nichols with being the first to call attention to these peculiar swamps in North America, in 1888–89. Those which Shaler observed were "mostly limited to the eastern portion of Maine, near the shores of the Bay of Fundy," but some of lesser magnitude were reported for New Hampshire, northern Michigan, and Minnesota. Similar bogs, with centers about 13 feet above their margins, have been reported in the province of New Brunswick by Ganong (1897).

Nichols (1919) described bogs of this type encountered in Maine, in which the elevation of the center above the margin varied from 2 or 3 feet to as high as 18 feet (e. g., Denbo Heath, covering several square miles in area). He asserts: "(1) that in the state of Maine raised bogs, in so far as they constitute a distinctive swamp type, are virtually restricted to the proximity of the seacoast; and (2) that in other portions of New England and of the eastern United States this type of bog is practically absent, although in occasional swamps it is possible to detect a slight elevation of the surface above the level of permanent ground water."

Warming (1909) has summarized concisely the characteristic features of "Hochmoore." They owe their development to the growth of sphagnum mosses which absorb water that falls in the form of rain or snow. Accordingly they are confined to

*Papers from the Department of Botany, the Ohio State University, No. 333.

regions of high precipitation and high humidity. They are called raised bogs or climbing bogs because they are commonly much higher near their centers than at their margins. According to Warming, their waters are practically free from salts or lime, and they are covered with bog mosses, chiefly species of *Sphagnum*, and with shrubby heaths. Nowhere in the literature can we find a reference to raised bogs in which the water contains an abundance of calcium salts and in which the dominant vegetation is other than sphagnum mosses and shrubby heaths, but such is the Urbana bog.

The presence of this unique habitat was first brought to the writer's attention in June, 1926, by Mr. Roscoe Franks, who realized its unusual character. It has lately been visited many times, in company with other botanists and classes from the Ohio State University.

The main portion of the bog occupies a lot eight or ten acres in extent, belonging to the McDonald Sisters in Urbana. Water which flows from the bog and from springs in the vicinity is used by the Urbana Tool and Die Co. to supply their reservoir, less than a quarter of a mile to the west. The water is distinctly alkaline, and the streams are usually choked with species of *Chara* and with watercress (*Radicula nasturtium-aquaticum* (L.) Britt. & Rendle. *Zannichellia palustris* L. and *Batrachium circinatum* (Sibth.) Rchb. occur in the streams and ditches, along with filamentous algae, which are being studied by F. B. Chapman. The coldest waters issuing from the bog on July 24, 1932, were at a temperature of 55° F., according to Chapman's data.

The dominant vegetation over the raised bog consists of a dense growth of shrubby cinquefoil (*Dasiphora fruticosa* (L.) Rydb.) Elderberry bushes (*Sambucus canadensis* L.) are scattered among the smaller shrubs, but are not nearly so numerous as the cinquefoils. Swamp rose (*Rosa carolina* L.) is also an important member of the plant association on the bog. Tufts of sedges, (principally *Carex emoryi* Dew.) grow everywhere on hummocks created by the crowns of shrubby cinquefoil. In some places, which are better drained, the sedges are replaced by Kentucky blue grass (*Poa pratensis* L.). Purple-stemmed Angelica (*Angelica atropurpurea* L.), swamp-milkweed (*Asclepias incarnata* L.), and evening primrose (*Oenothera biennis* L.) are perhaps the commonest large herbaceous plants and grow luxuriantly in this bog habitat.

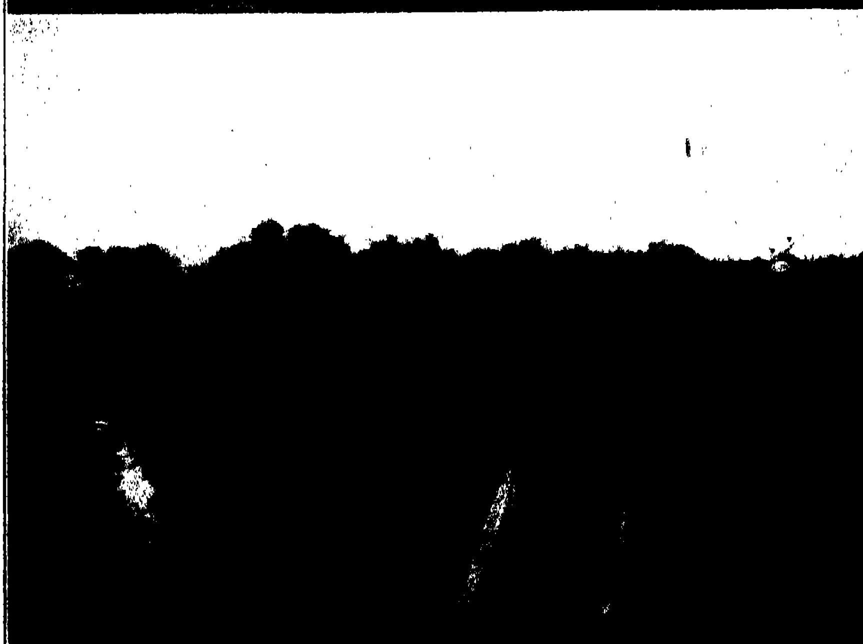

FIG. 1. (Upper.) Stream choked with water-cress in June, 1926.
Urbana Raised Bog.

FIG. 2. (Lower.) A view of the raised bog at Urbana, Ohio, October 7, 1931.

On the black peaty soil underneath the shrubs are small herbaceous plants, including crested shield-fern (*Dryopteris cristata* (L.) Gr.) small-flowered agrimony (*Agrimonia parviflora* Ait.) and several kinds of bryophytes and lichens. Two species of mosses have been identified by C. H. Coles as *Anomodon rostratus* (Hedw.) Schimp. and *Tortella caespitosa* (Schwaeg.) Linn. No sphagnum has been found here.

A preliminary traverse of the bog has been made by J. C. Kuenzel and O. D. Diller of the Central States Forest Experiment Station staff. The margins of the bog have an elevation of approximately 1050 feet above sea level, while the datum for the highest point is 1061. A few yards to the north of this point, a water-pipe has been driven into the peat. Although the top of the pipe is at least one foot above the ground, a steady flow of clear cold water flows out of the top, showing that a head of water pressure is maintained beneath the bog.

Test borings have been made by E. M. West, now Assistant Professor of Botany at Louisiana State University. A boring at the 1060-foot contour shows that 12 feet of water lies beneath the dense mat of roots which permeate the soil. It was there that the old road, previously referred to, crossed the bog. The road was formed by spreading gravel over the black peaty soil and is now marked by a luxuriant growth of blue-grass. Other introduced plants have been seen, including an apple tree, a peach tree, a few osage orange trees and a clump of *Ornithogalum umbellatum* L. A single specimen each of "buffalo currant" (*Ribes odoratum* Wendl.) and Japanese barberry (*Berberis thunbergii* D.C.) grow beside the old road bed.

Comparatively few boreal relics of the Northern Evergreen Forest Center are present in the bog flora. They include the following species:

Dasiphora fruticosa (L.) Rydb.	(*Potentilla fruticosa* L.)
Carex emoryi Dew.	*Vagnera stellata* (L.) Mor.
Galium boreale L.	*Anticlea elegans* (Pursh.) Rydb.

Many species, characteristic of marshy areas in general of the northeastern states and Canada, are included, as follows:

Dryopteris thelypteris (L.) Gr.	*Carex hystricina* Muhl.
Dryopteris cristata (L.) Gr.	*Carex lurida* Wahl.
Onoclea sensibilis L.	*Scirpus validus* Vahl.
Glyceria nervata (Willd.) Trin.	*Scirpus americanus* Pers.
Typha latifolia L.	*Scirpus atrovirens* Muhl.
Caltha palustris L.	*Rosa carolina* L.

Rumex britannica L.
Alsine longifolia (Muhl.) Britt.
Lythrum alatum Pursh.
Solanum dulcamara L.
Salix discolor Muhl.
Dracocephalum virginianum L.
Pedicularis lanceolata Mx.
Eupatorum purpureum L.
Cirsium muticum Mx.
Viola papilionacea Pursh.
Impatiens biflora Walt.
Galium tinctorium L.
Urtica dioica L.
Lycopus americanus Muhl.
Lobelia syphilitica L.
Senecio aureus L.
Eupatorum perfoliatum L.
Eupatorum maculatum L.

Several species of the Tall-grass Prairie Center are particularly evident in the flora of the raised bog. Among them are the following:

Andropogon furcatus (Muhl.)
Andropogon scoparius Michx.
Sorghastrum nutans (L.) Nash.
Filipendula rubra (Hill.) Rob.
Apocynum cannabinum L.
Koellia virginiana (L.) MacM.
Solidago ohioensis Ridd.
Allium cernuum Roth.
Steironema quadriflorum (Sims.) Hitchc.
Meibomia canadensis (L.) Ktz.
Mesadenia tuberosa (Nutt.) Britt.
Silphium trifoliatum L.
Rudbeckia hirta L.
Liatris spicata (L.) Willd.

In the swampy fields below and surrounding the raised bog a number of other interesting marsh species may be found, such as the following:

Valeriana edulis Nutt.
Lathyrus palustris L.
Triglochin maritima L.
Parnassia caroliniana Mx.
Solidago riddellii Frank.
Lobelia kalmii L.

A few weedy species also grow among the bog shrubs, among them the following:

Barbarea stricta Andrz.
Cerastium vulgatum L.
Nepeta hederacea (L.) Trevisan.
Convolvulus sepium L.
Dipsacus sylvestris Huds.
Erigeron ramosus (Walt.) B. S. P.
Asclepias syriaca L.
Parthenocissus quinquefolia (L.) Planch.
Leontodon taraxacum L.
Cirsium arvense (L.) Scop.
Lactuca canadensis L.

The origin of the raised bog at Urbana can be clearly understood only if we take into account some important historical factors. An early continental glacier (Wisconsin?) invaded the Urbana region. Two main lobes of the glacier, the Miami lobe to the west and the Scioto lobe to the east, were formed by the Campbell Hill promontory ten miles north of Urbana. The ice must have stagnated there for a long time, because deep deposits of gravel and boulders compose the lateral moraines on either side of the Mad River Valley. These deposits serve as

reservoirs of water and form the principal source of headwaters in the Mad River drainage.

The glacial drift at Urbana overlies limestone to a depth of 150 feet (Leverett, 1902). Land 1.7 miles east of the raised bog rises 130 feet higher than the margins of the bog, in a region of kame topography. Flowing wells or artesian springs are found in several places. It was around one of these artesian springs that the raised bog at Urbana developed. Supported by hydrostatic pressure below and held together by a mass of roots above, the bog shrub association of *Dasiphora fruticosa* exists here as a relic of an earlier type of vegetation which once occurred throughout the region. In spite of present climatic conditions, the constancy of water supply from artesian sources has maintained alkaline bog vegetation in a region where the prevailing natural vegetation is oak-hickory forest and tall-grass prairie.

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Geology of California.

To completely cover the geology of California in one volume is impossible. Reed has wisely touched only on the pre-Mesozoic geology and expended most of his labor on attempting to explain and clarify the geology from the base of the Triassic on, with especial emphasis on the Tertiary. This would appear to be an extremely wise course to take especially as his profession (Chief Geologist of the Texas Oil Company of California) has so ably fitted him to explain the complicated and often poorly correlated and identified Tertiary rocks of California. The work is enhanced with páleogeographic maps of the various periods from the Cretaceous to the recent. An appendix of important geographic names, an authors index, and a subject index are supplied. The use of the term "microphotograph" for photomicrograph is unfortunate but still a common usage. It is to be regretted that a fairly large scale geologic map could not be included as it would be of great value.—Willard Berry.

Geology of California, by R. D. Reed. xxiv+355 pp. Tulsa, American Association of Petroleum Geologists, 1933.

STUDIES IN THE BIOLOGY OF THE LEECH. I.*

THE SUBEPIDERMAL NERVE PLEXUS OF THE LEECH *Haemopis marmoratis* (Say).

JOHN A. MILLER
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INTRODUCTION.

A subepidermal network of nerve fibers similar to the one I have observed in the leech *Haemopis marmoratis* (Say), was observed in the epidermis of the earthworm by Retzius (1892), Smirnow (1894), Langdon (1895), Smallwood (1923) and Hess (1925). The subepidermal nerve plexus has not been previously described for the Hirudinea.

The purpose of this paper is to present a description of the subepidermal nerve plexus for the leech *Haemopis marmoratis* (Say), and the relation of this plexus to the muscles of the body wall, the epidermis and the central nervous system.

In a study of the nervous and muscular systems of the leech a definite nerve plexus was evident in the region between the bases of the epidermal cells and the basement membrane. A further investigation disclosed the nature of this plexus.

MATERIALS AND METHODS.

For the experimental work it was found desirable to use a single species of leech. The members of this group differ in habits and nerve patterns as well as in the nature of the integument and connective tissue. *Haemopis marmoratis* (Say) was selected because of its abundance in this locality (Columbus, Ohio). This species was further useful since it is a leech of large size and can be kept for considerable time in the laboratory.

N. Chandler Foote's modification of the Bielchowsky's ammoniacal silver method was used in the preparation of nervous tissue. Gross dissection with the aid of the Barrows' binocular bridge and 2% osmic acid were profitable.

*This is the first in a series of studies devoted to the anatomy and behavior of the leech.

THE SUBEPIDERMAL NERVE PLEXUS.

This part of the nervous system is composed of anastomosing nerve fibers which form a network in the region between the bases of the epidermal cells and the basement membrane. Branches from this plexus innervate the epidermis as well as the muscle layers. This network of nerves represents structurally, as well as physiologically, a true nerve plexus. This plexus differs from the other phases of the nervous system in that it shows no signs of the characteristic metamerism of the animal. This network surrounds the entire body. There are four regions of concentration of the subepidermal network located as follows: two regions just lateral to the mid-dorsal line and two just lateral to the mid-ventral line. (See Figure 2.)

From the epidermal sense cells arise neurofibrillae which extend into the subepidermal plexus. (Whitman, 1888.) From the subepidermal nerve plexus both intercellular and intracellular nerve fibers extend into the epidermis. From this plexus nerve fibers also extend inward innervating regions supplied by branches of the peripheral nerves. The subepidermal region is connected with the central nervous system through nerve trunks extending between the ganglia in the cord and the region of the epidermis. Branches of these epidermal nerve trunks innervate the subepidermal plexus as well as the epidermal cells. These nerve trunks are most obvious in the leech in the regions of the concentration of the subepidermal nerve plexus. (See Figures 2 and 3.)

From these observations and unpublished experimental data it is obvious that a definite relationship exists between the subepidermal nerve plexus, the muscles of the body wall, and the central nervous system. It is only on the basis of this deduction that certain expressions of behavior can be adequately explained. (Details of experimental proof and explanation will follow in a later number of this publication.)

The accompanying diagrams and photomicrographs will giver a clearer conception of this system in the leech.

SUMMARY.

(1) A subepidermal nerve plexus is present in the leech.

(2) The subepidermal nerve plexus is a network of anastomosing nerve fibers between the epidermal cells and the basement membrane.

(3) The subepidermal network surrounds the entire body.

(4) There are four regions of concentration of the subepidermal plexus: two dorso-lateral and two ventral-lateral.

(5) This system is supplied by fibers directly from the sense cell bodies in the epidermis.

(6) From this system nerve fibers extend directly to the muscles of the body wall as well as to the central nervous system.

(7) The subepidermal plexus serves as a reflex system of the body wall outside of the central nervous system.

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EXPLANATION OF PLATE.

Fig. 1. A camera lucida drawing, ×80, of a ventro-lateral concentration of the subepidermal nerve plexus. Note the inter-muscular as well as the subepidermal ramifications of these fibers.

Fig. 2. A drawing of a cross-section illustrating the arrangement of the muscles of the body wall and showing the distribution of the subepidermal nerve plexus.

Fig. 3. A photomicrograph, × 250, of a dorso-lateral concentration of the subepidermal and inter-muscular nerve plexus.

Key: C. Circular muscle, E. Epidermis, L. Longitudinal muscle, N. Nerve trunk, S. Subepidermal nerve fibers. Note the intermuscular ramifications of the subepidermal nerve fibers.

Note: The technique employed in securing and staining nervous tissue was of such a nature as to insure the staining of such tissue through specific nerve stains.


FIG. 1.

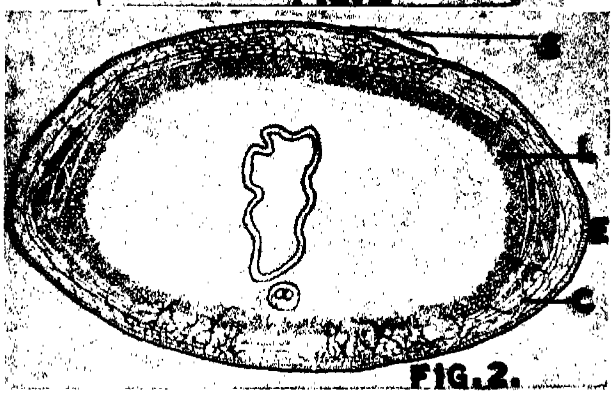


FIG. 2.

FIG. 3.

A NEW SPECIES OF LERNAEA (PARASITIC COPEPODA) FROM THE GOLDFISH.

WILBUR M. TIDD,
Ohio State University.

In the summer of 1930 some goldfish were sent to the author for examination by the proprietor of a goldfish farm in the southern part of Ohio. Examination revealed the presence of a number of parasitic copepods anchored firmly in the flesh of the fish. These parasites undoubtedly belong in the genus Lernaea, but a subsequent search of the literature has not revealed a species of this group to which they may be referred.

These parasites were first noted in the goldfish ponds in the summer of 1929. In 1930 three of the ponds were badly infested and the proprietor stated that almost every fish taken from them carried one or more of the parasites. In 1931 the infestation decreased considerably. Throughout the summer of 1932 parasites were found from time to time upon the fish and the degree of infestation roughly approximated that of the preceding summer.

This is the second time Lernaea has been reported as occurring upon goldfish. Enders and Rifenburgh (1928) reported a similar infestation at one of the large fish hatcheries in Indiana. They gave a brief description of the parasite with a few of the early stages in its life history. However, they did not refer it to any known species or describe it as a new one.

Lernaea carassii,[1] new species.

The type and paratypes of this species have been deposited in the United States National Museum and are recorded under catalogue numbers 67460 and 67461 respectively.

Female.—This species is characterized by the number and arrangement of the horns which arise from the cephalothorax and serve to anchor the parasite in the flesh of its host. The dorsal pair of horns (Fig. 1) fork distally into two unequal rami, the longer of the two continues at a slight angle to the

[1]Named after its host, Carassius auratus.

base of the horn, while the shorter one bends posteriorly and forms an angle with the first. These rami may be blunt or sharply pointed at their free ends. Occasionally a specimen is found in which one of the shorter rami is merely a small tubercle, making the dorsal horns unsymmetrical. The ventral horns are conical, slender, and sharply pointed. They usually curve toward the ventral surface of the body.

The free-thorax (Fig. 1) is slender in the region of the second pair of legs and gradually enlarges posteriorly. It is obscurely segmented and usually flexed in the region where it projects from the flesh of its host. Reference to the position of the egg sacks, pregenital prominence, and feet shows that the free thorax has undergone a rotation to the right, upon its longitudinal axis, thus carrying the egg sacks through an angle of approximately 90 degrees. Wilson (1917a) explained this phenomenon of twisting, or torsion, as being produced by the parasite twisting upon its longitudinal axis as it burrowed into the tissue of its host.

The pregenital prominence is usually well marked, simple or bilobed. The abdomen is conical, slightly upturned, and ends in two small anal liminae, each of which is armed with a long plumose seta, with two non-plumose setae on the outer margin.

As shown in Figure 3 the head is circular with a blunt rostrum projecting from the center of the anterior margin. The first antennae contain four joints, the second joint being the longest, all joints are heavily armed with setae on the anterior margin. Second antennae two jointed, the first joint being much the longest and unarmed. The terminal one ends in a curved claw, one large seta and two short ones, with three short setae along the inner margin. Second maxillae with two claws of almost equal size; maxillipedes two jointed, the basal joint unarmed, the terminal joint ending in five claws, near the base of these is a blunt process and immediately behind this is located a second and somewhat smaller process which is tipped with a minute seta.

The five pairs of swimming legs (Figs. 4–8) are quite typical for those of the genus as described by Wilson (1917b). Each of the first four pairs of legs consists of a broad basopodite and two three-jointed rami, each of which is armed with spines and long plumose setae. The small fifth legs (Figs. 2 and 8) are located immediately posterior to the pregenital prominence.

The egg sacks are long and narrow, and about one-third the length of the body; each sack carries about one hundred and eighty eggs. When ready to hatch the eggs are of a light green color.

The color of specimens preserved in a solution of five percent formalin and ninety-five percent alcohol, mixed half and half, is a grayish white. Young living specimens are a pale green, while old living specimens are a light brown color, and are often covered with a dense growth of a stalked protozoon, among which algae collect, giving the parasite the appearance of a piece of dirty string adhering to the fish.

Twenty-five specimens have been used in the above description. The following measurements are averages derived from the measurement of ten specimens carrying egg sacks. Body length (excluding horns and egg sacks) 9.78 mm., range 7.33 to 11.70 mm.; greatest diameter 0.50 mm., range 0.40 to 0.81 mm.; length across dorsal horns from tip to tip 3.16 mm., range 1.74 to 4.05 mm.; length of ventral horn 0.50 mm., range 0.40 to 0.58 mm.; diameter of egg sacks 0.25 mm., range 0.18 to 0.36 mm.

While these parasites are usually attached at the base of the fins a number have been found attached in the nostrils and over practically all other parts of the body. The depth at which the cephalothorax is buried in the flesh varies from just beneath the integument to a penetration of the body wall by one of the horns in such a manner that it comes to lie inside the body cavity in contact with the viscera. Quite often the flesh of the fish surrounding the horns swells up in a tumor-like growth, and the horns working about in this lump keeps it irritated and bleeding. When the parasite is removed from the tumor-like growth the horns and head are often found to be covered with a tough tissue which is very difficult to remove.

Frog tadpoles have been found, at the goldfish farm, which were carrying the adult parasites. In the laboratory the tadpoles of Rana species have been parasitized by introducing them into aquaria with goldfish which were carrying the larvae of the copepods upon their gill filaments. The region of the tadpole's hind legs seems to be the chief point of attachment. The mortality among these parasitized tadpoles is unusually high.

REMARKS.

In the arrangement of the horns this species is quite similar to an African species, *Lernaea temnocephala* Cunnington (1914), which was found upon *Barbus bynni*, a fish of the River Nile. While we know nothing of the appendages or egg sacks of *temnocephala*, as the description of the species was based upon a single, poorly preserved specimen, still from the author's description of the disposition of the horns it would seem to be very similar to the species described above. However, the dorsal horns of *temnocephala* end in rounded lobes and are not pointed, also *temnocephala* is said by Cunnington to lack evidence of segmentation, and the abdomen is parallel with the body axis, characters which will hardly fit the specimens under consideration.

LITERATURE CITED.

Cunnington, W. A. 1914. Proceedings, Zoological Society of London, pp. 827-828; pl. 1, Figs. 8, 9.

Enders, H. E., and Rifenburgh, S. A. 1928. A Preliminary Report on Lernaea, a Copepod Parasite on the Goldfish. *Proceedings of the Indiana Academy of Science*, Vol. 38, pp. 333-334.

Wilson, Charles Branch. 1917a. North American Parasitic Copepods belonging to the Lernaeidae with a Revision of the Entire Family. United States National Museum, Vol. 53, pp. 1-50.

1917b. The Economic Relations, Anatomy and Life History of the Genus Lernaea. United States Bureau of Fisheries, Vol. XXXV, pp. 165-198. Document No. 856.

EXPLANATION OF PLATE.

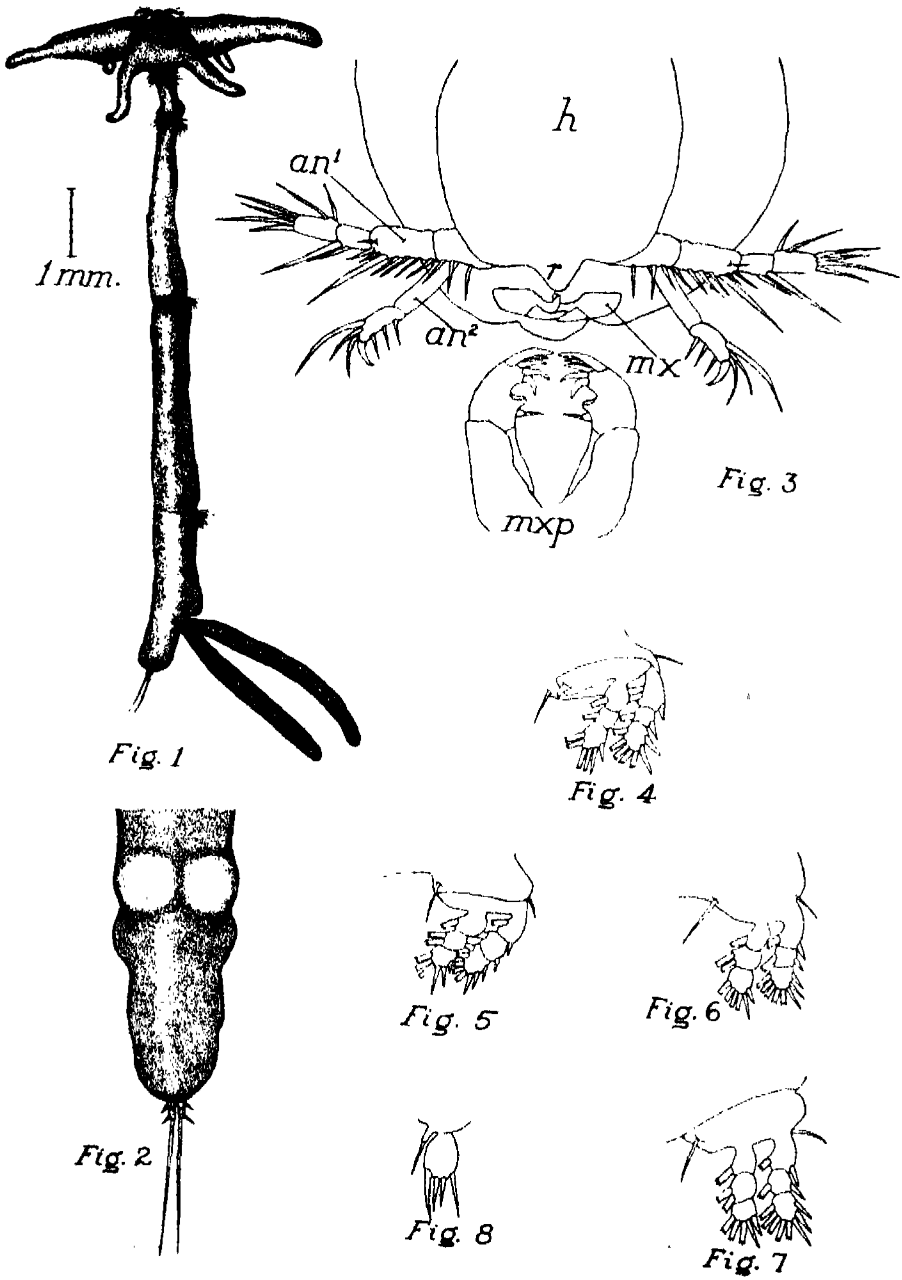
(All drawings were made from preserved specimens with the aid of the camera lucida.)

Fig. 1. Ventral view of female of Lernaea carassii.

Fig. 2. Ventral view of abdomen and pregenital prominence.

Fig. 3. Head and mouth parts: an^1, first antennae; an^2, second antennae; mx, second maxillae; mxp, maxillipedes; r, rostrum; h, head.

Figs. 4-8. First, second, third, fourth, and fifth swimming legs.


h
an¹
1 mm.
r
an²
mx
mxp
Fig. 3
Fig. 1
Fig. 4
Fig. 5
Fig. 6
Fig. 2
Fig. 8
Fig. 7

BOOK NOTICES

Fossil Plants.

The first paper of this publication, by Dorf, deals with the Pliocene flora of California. From some 16 scattered localities in California, of Pliocene age, are described some 34 species of fossil plants, distributed among 26 genera, of which *Quercus* is most abundant with 5 species. Of these 34 species, 8 are too poor to determine, 5 have been previously described, and 21 are described as new. The beds containing these plant remains are most abundant in the lower Pliocene and least abundant in middle Pliocene with an intermediate abundance in upper Pliocene. The close relationship of the present flora is well shown, details differing, however. The change from uniform Miocene climate to the diversified Pliocene is well expressed in this flora. Already there is evidence of climatic and physical barriers between the eastern and western North American floras.

The second paper, by Webber, deals with woods from the Ricardo Pliocene of Last Chance Gulch, California. Five genera of petrified wood are described from this Pliocene locality. There are four generic and specifically determinable fossils and one which can only be determined generically. One undetermined dicotyledon is recorded. These fossils show that the Mohave Desert region was less arid during the Pliocene. It is hoped that this useful paper will lead to more work on Pliocene woods.—WILLARD BERRY.

Studies of the Pliocene Paleobotany of California. I. Pliocene Flora of California, by Erling Dorf, pp. 1-112. II. Woods from the Ricardo Pliocene of Last Chance Gulch, California, by Irma E. Webber, pp. 113-134. Publication No. 412, Carnegie Institution of Washington, 1933.

Alcoholic Fermentation.

The author (see Arthur Harden, Nobel Laureate, 1929) has in this present edition more than doubled the size compared with the original edition of 1910. This book is apparently not "some brewers' handbook," but rather a detailed scientific discussion of the principles and theories involved in the fermentation processes. A general knowledge of Organic Chemistry, Physiological Chemistry or Bacteriology is essential to the proper understanding of this work. In addition to the description of the author's own investigation in this field there is included a very good survey of the work of other authors and an excellent bibliography (38 p.) of the literature up to the last of 1931.—WALLACE R. BRODE.

Alcoholic Fermentation, by Arthur Harden. Fourth edition, revised, 287 pp. New York, Longmans Green and Co., 1933.

Fresh-Water Algae.

American algologists have waited a long time for a comprehensive report on the algae of the United States that would be comparable to West and Fritsch: "British Freshwater Algae." Their patience has been rewarded in Smith's volume. The introduction discusses the ecology, methods of collecting, and recent evolutionary theories regarding the development of the freshwater algae. The morphology, reproduction, and taxonomy of all genera found in the United States, together with brief characteristics of the important species, occur. Each genus is illustrated by one or more original drawings. Amateurs will find especially helpful and comprehensive key to all genera, based on vegetative characters. The classes of algae discussed are Myxophyceae, Rhodophyceae, Heterokontae, Chrysophyceae, Bacillarieae, Chlorophyceae, Dinophyceae and Euglenophyceae. Students of the algae will find the book indispensable.—L. H. TIFFANY.

The Fresh-water Alga of the United States, by Gilbert M. Smith. 716 pp., 449 illus. New York, the McGraw-Hill Co., 1933.

INDEX TO VOLUME XXXIII

Date of Issue	Date of Issue	Date of Issue
25/4/58		
5-6-58		
22/12 69		
15-1-60		
11. 8. 61		
22 12 82		